WMO Aeronautical Meteorology Scientific Conference 2017
6 - 10 November 2017
Centre International de Conférences - Météo-France - Toulouse - France

Posters related to Session 1

Potential of polarimetric radar observations for aircraft icing detection?

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Speaker: Clotilde Augros

Polarimetric ground radars have become more and more popular in the past 10 years and are now deployed operationally in many developed countries (USA, UK, Germany, Japan, France, …). The particularity of these radars is to emit electromagnetic waves at both horizontal and vertical polarizations, which enable them to better characterize the properties of hydrometeors.

At Météo France, the use of polarimetric observations was proven to be very useful so far to discriminate non meteorological echoes, to correct for attenuation, to better estimate rainrate and to identify hydrometeor types. However, using differential reflectivity (Zdr) or specific differential phase shift (Kdp) to characterize cold micro-physical processes is still a challenge. These variables have generally low values above the melting level, and the accuracy of the operational measurements is too poor for localised estimations of Zdr and Kdp.

Nevertheless, previous studies have examined the polarimetric signatures of different cold microphysical processes. In particular, the polarimetric signatures encountered in the presence of supercooled liquid water (SLW) were investigated and led to the development of an icing hazard algorithm at NCAR (Serke et al, 2015). This algorithm includes several modules permitting the detection of freezing drizzle (Ikeda et al, 2009), SLW (Plummer et al, 2010), or mixed phase (Williams et al, 2011). In the SLW module, the icing hazard is higher when Kdp and Zdr have very low values, following the conclusions of Plummer et al (2010) who found that the mean values of Kdp and Zdr were slightly greater in regions of ice-only compared to mixed-phase (supercooled liquid and ice particles). However, Williams et al (2011) suggest that the coexistence of SLW and ice particles can also be characterized by relatively large Kdp and Zdr values, if the crystals grow as dendrites. This is consistent

with the study of Grazioli et al (2015), who explained that the presence of SLW layers (and riming) could be characterized by an enhancement of Zdr above the layer and by an increase of Kdp in this layer, due to the riming of supercooled drops on oblate crystals.

In that context, the objective of our study is to evaluate the potential of polarimetric observations for aircraft icing detection, and to develop our own icing detection algorithm adjusted to our radar observations. For that purpose, we have used a large data base of icing in-situ observations from two airlines to calculate distributions of Zdr, Zhh, Kdp and other associated parameters (spatial textures, standard deviations) for icing versus non icing cases. Our first results show that Zdr values are lower in average in icing regions compared to non-icing ones, which is coherent with the findings from Plummer et al (2010). It is more difficult to use Kdp for icing hazard detection as Kdp distributions for icing and non-icing conditions tend to overlap.

The global statistical analysis of the polarimetric parameters will be shown and a case study with strong SLW will also be presented. Eventually, the performances of our icing detection algorithm will be presented.

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Increased Flight Safety and Cost Savings for Airlines through Real Time Thunderstorm Information

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Speaker: Caroline Forster

Based on geostationary satellite data, the system Cb-global detects, tracks, and predicts thunderstorm hazards for aviation for up to one hour (=nowcasting). If uplinked into the cockpit of aircraft in real time and displayed to the pilot on an electronic flight bag (EFB) or a similar device, Cb-global information provides pilots an overview on the current thunderstorm situation beyond the limited view of the on-board radar. It enables a pilot to strategically plan a safe and smart flight route around the thunderstorms well ahead in time instead of flying tactical maneuvers and searching for gaps between the thunder cells. Cb-global post-analyses of several former aircraft incidents and accidents have shown that in these cases the pilots could have been warned of the thunderstorm hazard at least 30 minutes in advance, if Cb-global information would have been available to them. In a real time data link test over the South Atlantic in cooperation with Lufthans

a a safe route through an area with intense thunder cells could be found with the aid of Cb-global and a resulting fuel saving of approximately two tons was estimated for this case. All these cases indicate the great potential of Cb-global with respect to flight safety and fuel efficiency, but a systematic proof can only be done on the basis of a long-term dataset like In-Service Aircraft for a Global Observing System (IAGOS, www.iagos.org). In this study, flight tracks of IAGOS flights are compared to Cb-global detections, and it is shown that the flown routes avoid the hazardous regions marked by Cb-global in most of the cases. Obviously, the on-board radar picture, the pilot's basis for thunderstorm recognition during flight, is generally in good accord with the Cb-global detections. In addition, IAGOS meteorological measurements, e.g. ice particle number concentrations, temperature, and water vapor, along the flight routes that avoid the Cb-global hazard regions indicate that the flown routes are safe with respect to thunderstorm hazards.
In contrast, the few cases where the flight route leads through Cb-global hazard regions show high ice particle number concentrations within these regions and confirm that these regions should preferably be avoided. IAGOS is a unique data base to provide proof of the quality of Cb-global. From a large number of IAGOS cases examined, we can conclude that Cb-global is not just a meteorological information, but a decision making tool which pilots can rely on and which airlines can use to save fuel costs.

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Delhi International Airport- A Decade (2008-2017) of new Developments by IMD in Aviation Weather and Climate Monitoring, analysis and Information Services

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Indira Gandhi International Airport (IGIA) located at southwest of New Delhi, the India's national capital, has been a pride since its modernization started in Oct 2006 by PPP mode. Though, it covers a vast areas of around 42 Sq Km area(7kmx6km) and lies at heart of the city. But, before modernization started, it suffers full of aviation constrain when it had a single main RWY and two small terminals, with three set of RVR, two AWS and no doppler weather RADAR. But after PPP mode, as it strides in last one decade through rapid and historic modernization all have been reversed to bring back it to become global number one. It has now a 3rd RWY-a longest in India working since Aug 2008, redeveloped T1, an express city METRO and a new 3rd Terminal-a largest in Asia from Oct 2010, an aero city of 12 hotels and 5400 room, and now a new ATC-a tallest Tower in India. It has also been rapidly improving its ASQ index World rank which was 101 in 2006 has achieved now the number 2 airport in the world in 2016 as by ACI 2016, in terms of services to passengers and other service over 40 MPPA category. With all such advancement in infrastructure, the total number of flight operations in a decade increased 3-4 times to 1200 daily flight movements and 55.6 million passengers and its annual growth as on 2016 is still at 21% in terms of passengers, a highest in the world. Thus, it has already created its new history in world of aviation. In air side, ATC and meteorological terms, its two RWYs are CAT-III compliant RWYs (RWY28-10 and RWY29-11), both exact at parallel operation and 3rd is CAT II compliant RWY (RWY27-09) capable to land flights at 50m and 275m visibility respectively in case low visibility prevails. It has LVTO operational since Dec 2011. Hence, demands for precise weather information remained its utmost need for effective and safe operation at various segments and various user agency e.g. ATC and airlines for RWYs, taxing, glide path etc at various heights with timely early warnings/forecasts upto RWY wise while timely severe weather early warning for airport operator for terminals, airside and passengers safety and management. Briefly, if one classify Meteorologically and climatologically for the significant weather events of IGI Airport, it is highly vulnerable in each winter half, Oct-March for low visibility severe weather often falling to 0-200m due to longer duration Fog, smog and winter rains/low clouds predominantly occupy as the most disruptive aviation weather while for summer half of April-Sept, it is high temp of 45-50degc and convective thunderstorms, squalls, dust storms or monsoonal thunderstorms and intense rainfall are the disruptive severe weather.

For RWY weather, glide path and enroot weather monitoring, IMD-the meteorological service provider has accordingly in last 10-years have strengthened a)its Surface based RWY weather monitoring system where it has deployed a meso-network of world class Met instruments of 18 number of RVR-a highest in the world and five number of DCWIS/AWOS at three RWYs providing data from far 4-15km at each 1-15 second intervals to ATC via cable/wifi modems through dozens of display systems at various ATM seats and Live RVR in website b)its severe weather monitoring, nowcasting, forecasting systems which is presently equipped with two DWR(S-Band at airport and C-band polarmeteric DWR at city), RAPID-INSAT 3-D satellite products analysis systems upto 1-4km resolution at 30-minute gap from 6 imagers, CTT,RGB, day and night time micro-physics for CB/Fog detection at 24x7, Local upper air indices/winds GPS based system of regular two observations, airport's two Synergy-MFI based analysis and forecasting computer system for all real time data synoptic/satellite data and IMD web based NWP WDSS-II, GFS 12KM-T1534, WRF 3KM and their meteograms supported with two special Winter and summer IMD FDP projects implemented for improving airport Fog/TS/DS nowcasting and finally c) all these linked to a special communication systems operation in 2010, which has DWR product receiving work station, two Synergy analysis and forecast systems, OLBS, AMSS etc., working round the clock and providing all on-line products to various local and global users.

The MWO has also digitised all its data and built up an unique meso-climate information system using METAR data for providing intensity-duration, onset and lifting timings of day to day fog occurrences and their climatology at V<1000m, < 500m, < 200m and <50m to serve various category of flights using ILS 1964-2017 based upon which it provides claimtologcial guidance since Oct 2010, to regulator for scheduling various airlines flights as per their category while strictly restricting non-CAT-III flight for operation in peak winter of Dec-Feb during 1700UTC till 0500 in each winter of

2010-2017. Because of such unique world calss fog monitoring and forecasting system and claimetologcial guidance, IGIA has been becoming a zero diversion airport in the world irrespective of it has worst fog among all big airports in the world. It has also a special CDM fog cell headed by MET operation since Dec 2011 by effectively and fully

integrating met early warning on dense fog mornings with air traffic which have helped in reducing cancellation and diversions. It has also similar R and D works for summer thunderstorms using RVR/Wind data of METAR/RWY AWS/RVR for 1990-2017 to provide wind squalls, pressure falls, RVR fall in case dust storms and DWR tracks of these storms. It has also designed one Airport hazard information system for ready reference based upon data of 2008-2017 for providing impact based forecast/nowcast. With its AWS-RVR-DWR-RAPID-INSAT 3D-WDSS-II nowcast system, it provides 100% skill about likely severe storms at 1-3 hours in advance.

The intensity duration based fog climatological information system finds averages of fog events at two main different intensity of Vis<1000m and Vis<200m for Nov, Dec, Jan and Feb using 30-minute visibility data of IGIA, when analyzed for 37-years for 1981-2017 finds them as 10(91), 25(252), 25(255) and 15(110) days(hours) for fog of vis<1000m and 1(3), 6.3(35), 10.5(54.5) and 3(11) days(hours) for fog of vis<200m respectively for these four months. In total, it is 75 days covering 798 hours of total fog hours out of which it is 21 days and 204 hours of CAT-III dense fog, those IGIA normally experiences every winter with Dec-Jan almost all days have fog and vis hardly crossed 2000m. For summer, similar study finds IGIA normally has 60 thunderstorms(TS) per annum (as per data of 1995-2016) of which 89% occur in Mrach-Sept with lowest of 22 in 2002 and highest of 105 in 2010. Out of all these, on an average, 16 are associated with squalls and Dust storms while it may be as low as 2 in 2014 and as high as 27 in 1997 with squally wind and gusting speed as high as 140 kmph have been recorded. Their occurrences has strong seasonal behaviour with most of 89% occurred in Pre monsoon and monsoon covering March-Sept. They regularly have affected operation severely and following are some dates when it was worst. In the present study, we have discussed all such unique IGIA RWY-wise fog and storm real time monitoring and early warning systems, and also its unique claimtolgocial information system based upon longer period data which have both intensity and duration and RWY based occurrences information-a 1st of such work in the world.

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New Developments in Fog Monitoring and Forecasting System of Delhi Airport (2008-2017) with special emphasis on its eighteen RVR systems, RAPID(INSAT 3-D) based Fog RGB products and utility of new dynamic fog models and new Fog campaign data of 2015-2017

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Fog affects aviation at Delhi IGI airport severely in each winter of Nov-Feb. It has presently three RWY with two are of CAT-IIIB ILS to help flight landing upto 50m of RVR in dense fog. With its huge daily traffic recently increased 1200 flights per day and with various category of flights operating, it needs all details about fog development spreading to various RWY, intensification and dissipation by accurately and instantly monitoring and reporting in current weather/RVR from all RWY ends and then a nowcast-trend for 0-2 hours validity for take off/landing(LVTO) decision by ATC/Airlines and forecast of 2hours upto 5 days lead time, to starts of fog event occurrences informing about characteristics of likely fog events e.g. timing of onset and lifting at various intensity of fog based upon visibility/RVR reduction at shallow, moderate, dense and very dense stage of fog overall at IGIA and at each RWY ends so that airlines and ATC/Airport operator makes all advance preparation to suitable minimize its impact and reduce diversion. The same information is also need by these users for all other nearby airports for deciding flight diversions in case fog makes all RVR to all below 50m closed down IGIA. To manage the fog related disruption at IGIA Delhi effective, Met office at IGIA has implemented a FDP-Fog and collaborated with other country's premier institution like with IAF, CAS-IID, and IIITM Pune, NCMRWF and SAC- Ahmadabad 2008-2014 and implemented an integrated Fog information system which includes:

a) Fog micro-climatological information system developed based on hourly vis data of 1981-2005 and RVR data of 1989-20016 for IGIA that has been updated time to time and has all detail aspects of past fog- micro claimtic information, including RWY wise variation to help airlines/ATC for better fog preparedness and to understand the depth of impact in case of proper fog plan is not implemented for time to time as per increase of traffic and passengers

b) Real time fog monitoring at RWY through surface based eighteen RVR-a highest at any airport in the world, and provide all RVR values to ATC, Airport operator, airlines in live through websites and fog monitoring across the region using vis data of adj airports and Kalpana based day time satellite fog monitoring and MODIS night time fog pictures

c) Fog nowcasting and forecasting using Satellite fog detection scheme of Kalapan-MODIS, better observational facilities like AWS, RVR and utility of DWR to look at clouds, new empirical fog models and using MOS from WRF models(Jenamani, 2009, 2015, Goswami and Tyagi, 2007) d)SMS-Web based and Live RVR based Dissemination System for instantaneous transmission of fog early warnings to users all around the world on fog features at IGIA.

In this paper, we have reviewed all Indigenous available method (IMD Empirical fog models, CMMACS dynamical fog model and IAF Fog model used in FDP- FOG for Delhi implemented in 2008-2012 and performance of these fog models including the skill of real time fog forecast. We have also discussed Check lists of nowcast and Forecasts methods further developed in 2012-2015. We have assessed skill of Real time Fog Forecast and its success in 2008-15 in terms of significant reduction of diversion. During last two fog season of 2015-17, many significant new progresses have been made both from new observational and satellite fog detection aspects and development of new dynamic fog models. Indian satellite fog detection capacity has been made very rapid progress with lunch of new INSAT 3-D and its operationalization from Dec 2014 which has SIR, VIS imagers at 1 km and other four cloud imagers are of 4km and WV of 8km resolution and being its all products analysis systems could be analyzed upto 1-4km resolution at its on-line analysis system RAPID (http://rapid.imd.gov.in/) at 30-minute gap including facilities of it has CTT,RGB, day and night time micro-physics for Fog detection at 24x7 and have full potential to monitor day and night time fog across the region. We have discussed and validate its fog products on how in last two winter, it has immensely helped in capturing major fog spells at 24X7 and subsequent 1-3h nowcast with facility available for at both day –night fog monitoring(before it was only day time Kalpan vis fog picture).We have also validated night time fog and low cloud detection using RGB products from channel subtraction of BRT TIR1-MIR in collaboration with SAC for 2015-2017.

Besides INSAT-3D better fog detection system India ahs adopted, it has also successfully conducted two consecutive joint special fog campaigns at IGIA for winter of 2015-16 and 2016-17 where a new Radiometer (Sachin, Bhatt, Thara, Jenamani etal 2017-www.currentscience.ac.in/Volumes/112/04/0667.pdf), Sodar, wind profiler and 28 other equipments were deployed during Dec-Feb for understanding boundary layer features along with fog microphysics and role of various pollutants and precursors of fog nowcast/forecast. It was huge success as it captured 23 dates of 135 hours in Dec-Jan 2016-17 while 16 dates of 86 hours in 2015-16 Real time data from Fog campaign especially Radiometer's Vertical distribution of vapour density and humidity and inversion layer building up by early evening along with lower levels winds from SODAR and pollution type and concentration(ammonia built up) also have helped in improving nowcasting of onset of development of Dense Fog at IGIA on some dates.

In last winter, IGIA has fog forecast products from two new dynamical models which were run day to day from NMCRWF-NCUM where spatial vis forecast were prepared and WRF Chem using GFS and NCUM BC where fog was subjectively determined form their LWC Forecast. Both products are validated using surface vis and Radiometer data and skills are computed for fog of 2016-17.

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Hazards of bora wind at Dubrovnik Airport

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Speaker: Igor Kos

A gusty downslope windstorm called bora is the most important weather phenomenon at Dubrovnik Airport, significantly affecting safety and efficiency of air traffic. It has been recognized that there are two different types of bora, so called standard and deep bora, which produce different problems such as crosswind, turbulence and wind shear on both approaches and touchdown zones of the airport. There have been many studies of bora at the North Adriatic, and lately at the Middle Adriatic, but very few at the South Adriatic where Dubrovnik is situated, and there was always a lack of measurements in the area.

Using wind data from anemometers situated at both runway thresholds and vertical profiles of wind from operational numerical model ALADIN/HR, bora episodes have been clustered in standard bora and deep bora cases during the period 2007-2014. It was shown that the mean wind speeds and gusts during standard bora at RWY12 are greater than those at RWY30. However, during deep bora, wind speeds at both runways are comparable. Also, the difference between mean wind speed and strongest wind gusts is greater during deep bora than during standard bora. Comparing with ALADIN/HR model, it was shown that although the model predicts the onset and duration of bora episodes well and can distinguish between bora types correctly, it cannot reproduce the strong wind speeds at 10 m above the surface. Using the data from TAFs, we have shown that the forecasters are better in predicting wind speeds during both standard and deep bora episodes.

These promising results, along with the continuous problems that bora causes to aircraft operations at Dubrovnik Airport, are motivating Croatia Control Ltd. (both ATS and MET provider in Croatia) for preparation of the "Project Bora Dubrovnik". They prepare this project in collaboration with several partners: Croatian Meteorological and Hydrological institute, Faculty of Science and Faculty of Traffic of University of Zagreb, Croatia Airlines and Dubrovnik Airport. Through research and innovations this project aims to create new products and services in order to raise safety and efficiency of air traffic at Dubrovnik Airport. The project has several specific goals: to introduce measurements of bora winds at and around the airport, to improve the precision of operational numerical model, to reduce the closing times of Dubrovnik Airport due to bora winds, to reduce the costs of airline operators due to cancelled and diverted flights, and to improve the overall safety of aircraft operations.

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Wind gusts forecast by numeric weather prediction model

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Wind gusts can reach significant values even at medium winds. Knowledge of total wind including gust is extremely important for aircraft landing decision. Including gusts in aviation forecast results better forecasts for landing condition at airports. However numerical atmospheric models are designed to represent average winds, not gusts. There are several approaches to estimate wind gusts. One is statistical approach which is mainly based on estimation of wind speed distribution at the location. Second is physical parameterization of wind gusts. This group of methods range from surface dependent gust factor methods to complex methods using different variables that can be resolved by numeric weather models.

Most frequently used methods were realized using WRF-ARW model forecasts. They are compared with each other and their performance in different cases was analyzed. On this basis a new hybrid method is suggested. According to stability type of atmospheric boundary layer different methods for estimation were chosen. These lead to obtain predictability of wind gust over 22 m/s over 80% (comparing with 10-27% of other methods) in autumn and winter season.

As this hybrid method takes into account different gust formation mechanisms it has relatively same accuracy throughout a year. All these methods are based on combination of different numeric model variables. Each of them has its own accuracy and it is often difficult to choose model configuration resulting best forecast of each variable. However for the concrete task of gust forecasts it is possible to choose optimal configuration. Influence of different model parameterizations is discussed. Concerning convection it is often mentioned a connection between wind gusts and thunderstorms, there is a usage of the same methods for the both phenomena thus they are both often connected with deep convection and have same predictors. So possibility of application of methods used for thunderstorm prediction for wind gusts forecast is discussed. It is shown that thunderstorm methods overestimate severe gust occurrence.

This work is partly supported by RFBR according to the research projects №16-05- 00822, 16-05-00704, 15-05-02395.

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Observation products mixing several sources (radar, satellite based, ground based)

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At the observation department, we developped methods that mix several sources of observations. Some of them are developed for the aeronautical use : they focuse on low cloud base or visibility, but also on automatic CB detection in the terminal aera.

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Cloud top height and microphysics from meteorological geostationary satelliteS using EUMETSAT NWCSAF SW

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Speaker : Hervé Le Gleau

In the frame of the EUMETSAT NWCSAF, Météo-France has developed a software to retrieve the description of the cloud cover (cloud types, cloud top height and cloud microphysics) from a set of meteorological geostationary satellites including MSG, GOES, Himawari.
This presentation focuses on the cloud top height and cloud microphysics (thermodynamical phase and droplet/ice crystal size at the top of the cloud; cloud optical thickness and liquid/ice water path). The main features of the retrieval algorithms are first summarized. Validation results for MSG and Himawari, obtained using micro-wave imagery and space-born radar and lidar measurements, are then presented. The operational retrieval by Météo-France of cloud top height and microphysics products for aeronautic application on a global scale is finally illustrated. The use of these NWCSAF global products for aeronautic applications is also covered by other Météo-France presentations during the conference.

The software can be obtained from www.nwcsaf.org.

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Towards an increased usage of aeronautical meteorological observations in the convective scale model AROME

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This presentation will describe the current operational usage of meteorological observations from commercial aircrafts in the operational convective scale model AROME and will highlight their importance on short range weather forecasts. Results from Observing System Experiments, where additional observations available from the EUMETNET E-AMDAR programme in May-June 2017 in order to increase the resolution of vertical profiles are withdrawn from the assimilation system (denial experiments), will be presented in terms of forecast skill scores. Finally, short-term plans in order to assimilate in AROME much more aeronautical meteorological observations (wind and temperature) that can be deduced from the ADS-B/MODE-S acquisition will be provided.

Climate use by Aeronauts

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The use of space by aeronauts depents scientifically on the Meteorological parameters and their interpretations. The present system of giving forecasts namely Take off parameters, Arfor, Tafor, Sigmet is in practice. For this the parameters is being taken primarily by manual methods and Technical Methods such as by remote methods such as by use of sensors (valus/reflectants) and the values by getting through conventional (digital)means. And others are by Reflection method pictorial studies i.e by weather radar and Satellite imgeries.Foremost aspect is that the care should be taken that the results should be of error free. This can be achiveb by manual methods (conventional). Wheras the measurement of reflectivity and their use sometimes not reliable and their accuracy should be established on long duration studies. The coutries contribution in manual values is becoming less compared to auto matic values. And the getting of manual values from various parts of the globe is time consuming. This difficult situation should be minimised with the co-operation of the member countries.

In the circumstances there should be studies to establish differrences between conventional and non conventional methods of studies.

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Improvisation of indigenously developed Current Weather Instrument System for Airport Meteorological Services

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Aviation meteorological services are one of seven strategic priority areas under the WMO Strategic Plan 2016 – 2019. The plan seeks to improve the ability of National Meteorological and Hydrological Services (NMHSs) to provide sustainable high-quality services in support of safety, efficiency and regularity of air traffic management worldwide, with due account to environmental factors. In recent years India has done significant progress in improvement of efficiency and safety of domestic and international aviation through implementation of Global Air Navigation Plan of the International Civil Aviation Organization (ICAO).

India Meteorological Department is a nodal agency responsible for providing aviation meteorological services including installation, commissioning and maintenance of airport meteorological instruments at all civilian airports across the country. In order to provide aviation services, IMD has commissioned various aviation meteorological instruments such as Integrated Automated Aviation Meteorological Systems (IAAMS), Current Weather Instrument System (CWIS), Distant Indicating Wind Equipment (DIWE) and “Drishti” transmissometer systems at airports across the country.

The present CWIS was developed in the year 2008. It consists of field components installed at the runway touchdown zone and indoor components installed at the Air Traffic Control (ATC) tower and Met. Briefing Room (MBR). The present system entails more hardware for maintenance and dependency on different vendor for spares of slave display units and other hardware components.

In this paper, we present improved design of indigenously developed CWIS with minimal hardware. The data logger at filed site is based on open architecture (real time Linux) and is modular in design. It is scalable in terms of input and output channels and measurement and sampling requirements of end users. Third party GPRS modem can be interfaced with the logger. The data logger configuration can be done Over The Air (OTA). The data are stored in accordance with ICAO regulations. Dew Point temperature, QNH and QFE are also derived and stored. The data transmitted from multiple field systems installed along the runway are received in a desktop computer (Data Acquisition PC) in MBR/ATC via wireless or cable communication mode. Data Acquisition PC stores data of received and derived parameters with time stamp in real time and outputs the received data over RS232 port of PC. 1-min, 2-min and 10-min average data along with instantaneous data and metadata are stored in suitable r
elational database. The archived data are available to PC based data display software for real time display of data in ATC and MBR. The data are displayed in both numerical and graphical form. Multiple software based generic slave displays can be provided.

The advantage of this system is that it removes dependency on vendor for hardware. Data can seamlessly be made available in displays and website. The system is easy to maintain and manage.

Key Words: CWIS, Open Architecture, Display system

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Improving the nowcasting of hazardous weather phenomena by assimilation the lightning-seeking network data

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Speaker: Konstantin Rubinstein

The report studies the system for the nowcasting of thunderstorms, hail, squalls. The system based on the lightning-seeking network. Currently, the forecasting of lightning and related hazards is based on estimates of atmospheric instability indices. Alternative forecasting technique is the direct numerical simulation of convective cloud electrification.
However, the atmospheric instability analysis doesn't explicitly consider electrical processes occurring in convective clouds.
On the other hand, the using of numerical models requires the resolution of the uncertainty problem associated with the application of various schemes for the microphysical processes parameterization.
The cumulonimbus (Сb) electrification model is a set of equations describing the processes of the generation and separation of electric charges in convective clouds, constants and profiles of meteorological data. The process of charge generation is described by equations taking into account the diameters of interacting hydrometeors (snow, ice particles, graupels, cloud droplets), the fraction of colliding particles, the resulting charge from a collision/merger, gravitational and turbulent speeds of particles' sedimentation and air temperature. The model includes the equations describing non-inductive, inductive mechanisms of charging and its combination – the integrated scheme.
The input data for the electrification model (meteorological data profiles) are obtained by the hydrodynamic mesoscale model WRF-ARW (Weather Research and Forecast) that allows to predict the parameters of the atmospheric electric field (total volume charge, potential and electric field intensity) including specific to thunderstorm activity.
The choice of the charging mechanisms is performed on the basis of a specialized algorithm for validation of the electrification model using by the data of the lightning-seeking networks. The techniques of the lightning-seeking network data assimilation in the numerical atmospheric model make it possible to obtain a complete picture of the convective cell and to improve the forecasting.

This work was supported by the RFBR (Russian Foundation for Basic Research) under grants А 14-08-01105, А 15-05-02395 and A 16-05-00822.

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Emerging challenges and opportunities in Aircraft Observations And Reports

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Speaker: Vivek Sinha

Aircraft observation has evolved as an integral part of meteorological observation and reporting scheme, and perhaps most important source of real time upper air observation. Around 20,000 AIREP messages besides 4000 AMDAR messages through WMO-GTS stream. INDIA has recently implemented the reception of AIREP through ADS-C in one of its FIR, with very encouraging results particularly from the data sparse oceanic region. As the trend shows AIREP through ADS-C and/or CPDLC is likely to become the mainstay of reception of aircraft report. However an analysis of such report indicates variation in reporting format within AIREP, besides a significant difference in the content and frequency between AIREP and other reports like AMDAR, ACARS. Handling of such varied data format or applying a uniform quality check in any automated system poses a challenge. The present procedure in which all aircraft reports are identified with the respective flight number makes it difficult to identify individual aircraft with faulty or unreliable sensors.

In course of implementation AIREP through ADS-C, the requirement of reporting of random events like turbulence, wind shear, icing or volcanic ash has posed another set of technological challenge as the periodicity contact is otherwise predefined. The resolution of these issues requires intervention at multiple levels, form modification in on board flight management system, to modification in ground based reception system. This in turn requires a wide ranging and protracted deliberations between WMO, ICAO, ANSP and aircraft manufacturers.

The increased frequency of encounter of near cloud turbulence (unlike the in cloud turbulence which is easier to detect, hence to forewarn.

Another area of attention is the requirement for measurement and reporting of humidity which has so far remained restricted to AMDAR enabled aircrafts, primarily because it requires retrofitting of additional sensors in aircraft. Considering the limitation of satellite channels in accurately assessing the moisture (other than from middle atmospheric level) makes it logical to consider expanding the scope of AIREP to mandatorily include the moisture reporting.

Exploring the potential of data link, INDIA has taken another initiative for dissemination of D-VOLMET to cockpit using the ACARS data link (SITA- Pre FANS). With some system modifications it is feasible to disseminate targeted SIGMET and other warning directly to FMS using the link. Considering the operational and economical benefit of such initiatives; this may incentivize the other stake holders like manufacturers and airlines operators to invest in technology upgradation.

To conclude with, the leverage of aeronautical meteorology as service can be used to meet the requirements of meteorology as science, in the process creating a mutually beneficial and cost effective system for all the stake holders.

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Nowcasting of Mesoscale Convective System Using Satellite Data

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Speaker: Putchaphan Sirisap

In southwest monsoon season, the Mesoscale Convective System (MCS) plays an important role in the weather of Southeast Asia. The severe weather events such as heavy rain, hail storm and strong wind are governed and driven by the mature stage of this system. Nowcasting, which refers to forecasting for a very short time range (up to 6 hours) is useful for predicting the development and dissipation of such systems. Satellite data, acquired from geostationary satellite provide valuable inputs for nowcasting due to their high spatio-temporal resolution. Scientists are continuously striving towards newer techniques to track and nowcast convective systems with higher accuracy and improved lead times. In this context, in the present study an image analysis technique i.e. the Source Apportionment (SA) algorithm has been applied for predicting convective system using Kalpana-1 satellite sequence of images. The algorithm uses neighborhood search criteria to extract contiguous convective pixels. The extracted pixels are then used to trace the evolution and predict the development of MCS, using some identified nowcasting parameters.
The present technique has been applied over a geographical region (50 S–250 N, 850 E–1150 E) covering Thailand and adjoining oceanic regions for convective systems case studies during monsoon season of 2012. For tracking and forecasting, analysis of new nowcasting parameters has also been carried out. The results of study show that temporal variation of effective radius of convective system and effective radius for deep convective zones are suitable for identifying the mature stage while evolution of their slopes are good for identifying the dissipating stage. Additionally an analysis of different thresholds was also carried out to investigate their effects on forecasting methodology. It is seen from the study that model is able to predict the mature and dissipation of a MCS with a lead time up to 3 hours. An improvement in accuracy and lead time will be an area for future research.

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Multi-Point Visibility Measurement System and Accuracy

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Speaker: Hongda Tai

Accurate and automatic measurements of visibility are of great importance for aircraft takeoff and landing. This article reports a multi-point visibility measurement system (MVMS) to measure and calculate the atmospheric transmittance, extinction coefficient and meteorological optical range (MOR). The relative errors of the atmospheric transmittance and MOR measured between the multi-point visiblity measurement (MVM) method and the transmissometer method were analyzed and compared using MVMS. The results of the comparison demonstrated that the atmospheric transmittance and MOR measurement errors obtained with MVM are much lower than those obtained using the traditional transmissometer method. To validate the degree of improvement of the measurement result between the two methods, an experiment was conducted on the MVMS in an atmospheric environmental simulation chamber. The experimental data were simultaneously processed by the MVM and the traditional transmissometer method. The results revealed that the MVM can effectively improve the accuracy of the MOR measurement under different visibility conditions and that as the visibility decreases, the improvement of the accuracy of the MOR measured by MVM increases. The greatest improvement in the measurement accuracy was 27%. Thus, MVMS can be used not only to calibrate visibility meters but also to provide standard values of visibility for performance evaluations of new visibility instruments.

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Performances and Benefits of Coherent Doppler LIDARs in Aviation Weather

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Speaker : Ludovic THOBOIS

Weather is one of the major causes of flight delays and accidents. On the one hand, atmospheric hazards like wind shears should be monitored with high spatial and temporal resolution sensors in order to reduce their impact on air traffic for improving safety. On the other hand, weather conditions like wind, visibility or cloud have a direct impact on the efficiency of air traffic management (ATM). If since several decades, significant progress have been performed to deploy advanced sensors at airports like the introduction of weather radars in compliment to common and basic surface stations, new technologies like Doppler LIDAR sensors are becoming more and more mature for being used operationally.

The current study will review the different existing technologies of Coherent Doppler LIDARs (CDL), their history, expected perspectives, as well as their advantages and drawbacks. If CDLs allow to obtain high spatial (5m to 200m) and temporal (1 Hz to 20 Hz) resolution and accurate wind measurements (typically 0.5m/s), their operational use remains relatively limited on worldwide airports. The study will also show the intrinsic performances in terms of data availability, measurement range and accuracy and precision on wind measurements of CDLs though theoretical formula simulations and field experiments. The study will then highlight the potential roles of CDLs in aviation weather in regards to other types of meteorological sensors like radars or ceilometers and the way CDLs can be combined with other met sensors (surface measurements, radars, ceilometers).

Besides, the study will remind the outputs of the recent published ISO standard on Doppler Lidar for meteorology illustrating the recent advancements in the maturity of such sensors. Finally the study will present three use cases of CDL. The first use case will be the quick adoption of this technology by forecasters of Lanzhou airport in Gansu, China for detecting low level and dry wind shears. The second use case will focus on the interest of resolved wind measurements to gather advanced ATM systems able to optimize the runway occupancy times (ROT) which are highly dependent on weather conditions and wind especially. Within a Future Sky Safety project, a field experiment has been conducted at Paris-Charles de Gaulle airport to determine the benefits and to reach a proof of concept of such new ROT system. The third use case is at the frontier between the aviation weather and the air traffic worlds. It will show a direct operational use of huge amount of CDL data collected at Paris-Charles de Gaulle airport to better mitigate the risk of the encounters of wake turbulence induced by aircrafts so as to minimize the distance separations between aircrafts.

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European Natural Disaster Coordination and Information System for Aviation (EUNADICS-AV)

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Speaker: Gerhard Wotawa

Commercial aviation is one of the key infrastructures of our modern world. Even short interruptions can cause economic damages summing up to the Billion-Euro range. As evident from the past, aviation shows vulnerability with regard to natural hazards. Safe flight operations, air traffic management and air traffic control is a shared responsibility of EUROCONTROL, national authorities, airlines and pilots. All stakeholders have one common goal, namely to warrant and maintain the safety of flight crews and passengers. Currently, however, there is a significant gap in the Europe-wide availability of real time hazard measurement and monitoring information for airborne hazards describing "what, where, how much" in 3 dimensions, combined with a near-real-time European data analysis and assimilation system. This gap creates circumstances where various stakeholders in the system may base their decisions on different data and information.

The H-2020 project EUNADICS-AV ("European Natural Disaster Coordination and Information System for Aviation"), started in October 2016, intends to close this gap in data and information availability, enabling all stakeholders in the aviation system to obtain fast, coherent and consistent information. The project intends to combine and harmonize data from satellite earth observation, ground based and airborne platforms, and to integrate them into state-of-the art data assimilation and analysis systems. Besides operational data sources, data from the research community are integrated as well. Hazards considered in the project include volcano eruptions, nuclear accidents and events, and forest fires. The availability of consistent and coherent data analysis fields based on all available measurements will greatly enhances our capability to respond to disasters effectively and efficiently, minimizing system downtimes and thus economic damage while maintaining the safety of millions of passengers.

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Objective forecasting product system for aviation meteorological services in China National Meteorological Center

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Speaker: Bo Yang

As national meteorological department, China National Meteorological Center (NMC) takes responsibility for guidance of aviation weather services. After years of development, a relative systematic and complete objective forecasting product system has been formed. This objective forecasting product system is introduced in this article. The core product of the objective forecasting product system is the model product. NMC has multi-scale multi-purpose numerical model products developed by itself (Global model, Regional model, Ensemble model, Nuclear contamination transmission model, Environmental model, Typhoon model, Meso-scale model). Basing on the output of the model and the extrapolation of different types of irregular observation data, a variety of products based on model and extrapolation products are formed. For the short-time forecasting and nowcasting, there are extrapolated products based on radar, satellite and lightning data. For the short term forecasting, there are products based on machine learning and ingredient-based method. In terms of product coverage, there are terminal forecast, air route forecast, regional forecast and global forecast. Other products include turbulence, ice accumulation, convection, wind shear, ash monitoring and forecasting, typhoon forecasting, etc. By using of various objective forecasting techniques, basing on numerical model and different types of irregular observation data, a comprehensive and complete objective forecasting product system have been formed in China NMC. It strongly supports the operational needs of aviation meteorological services.

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Posters relating to Session 2

Standby mechanism and route for transmission of SIGMET, METAR and TAF for efficient distribution

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Speaker: Sourav Adhikary

At present the Cyclone SIGMET (WC), Volcanic Ash SIGMET (WV) and SIGMET other than WC and WV i.e. WS SIGMET are transmitted by designated Meteorological Watch Office (MWO) for their respective Flight Information Regions (FIR). The SIGMET is transmitted by the concerned MWO through AFTN Network to predefined AFTN Addresses. Each SIGMET has a predefined header showing the ICAO code of originator. But if the designated MWO fails to transmit the SIGMET Bulletin due to natural calamity or system failure, then there is no standby mechanism to transmit the SIGMET Bulletin. In this paper, a standby system is proposed. If a designated MWO is failed, then the possible ways to transmit the same bulletin by the nearby MWO are discussed in this study. It is proposed to define one standby MWO for each designated MWO. Another mode of transmission of SIGMET is through the Global Telecommunication System (GTS). In the SIGMET Manual, though there is specific mention of recipient AFTN addresses for SIGMET messages, nothing is mentioned regarding transmission of SIGMET messages over GTS. In case of failure of AFTN link of MWO, transmission of SIGMET messages over GTS to designated destinations can be achieved. This study shows how GTS can be utilized to transmit SIGMET. In case ROBEX bulletin, METAR and Terminal Aerodrome Forecast (TAF) are transmitted to AFTN Network by specified ROBEX centres only. Here also there is no backup arrangement for the designated ROBEX centres. This study suggests a backup arrangement for the ROBEX centres. This study suggests a mechanism to shift the operation of one ROBEX centre to another nearby ROBEX centre. This study also proposes a mechanism to use the GTS network as an active standby network to the AFTN network to transmit the ROBEX bulletins of METAR and TAF to designated centres.

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Tracking commercial aircraft based on the detection of micro-discharges with Lightning Mapper Arrays during penetration of electrified convective clouds and ice clouds

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Speaker : Eric Defer

Amongst the different techniques applied to detect and locate lightning flashes, Very High Frequency (VHF) time of arrival lightning mappers offer unique regional 3D mapping of both intra-cloud and cloud-to-ground lightning flashes with high detection efficiency. We investigate herein the use of Lightning Mapping Array (LMA) lightning data for operational storm warning and monitoring applications around airports. LMA data from LMA systems in the US and in Europe such as the Colorado LMA (CoLMA) (USA) and the SAETTA network in Corsica (France) are utilized.
In addition to detecting natural lightning flashes and flashes triggered by commercial aircraft when flying in electrically charged clouds or in ice clouds, the LMA also detects static discharges from aircraft when flying through ice clouds. This is dependent on the sensitivity of a particular VHF lightning mapper.
We will first present the LMA technology. Then we will discuss on the main characteristics of the VHF r induced by the micro-discharges based on records from the CoLMA and SAETTA and also from the HyLMA specifically deployed in South-East of France in support to the HyMeX Special Observation Period campaign (July 2012 to November 2012). These characteristics will then be compared to the typical characteristics of natural lightning flashes and of a few aircraft triggered lightning flashes recorded so far by these LMAs.

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Investigating Airport Operations under a Lightning Threat: Balancing Lightning Safety with Operational Efficiency

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Speaker: Wiebke Deierling

Lightning can harm outdoor workers servicing gate-side aircraft or performing other duties on airport grounds. Typically airline and airport stakeholders have put safety procedures in place to halt outdoor work (ramp closures), and bring personnel inside to safety. These ramp closures, however, cause air traffic delays. This study examines the risk of outdoor workers exposed to lightning threats based on various safety rules and decision support information and compares it to the magnitude of traffic delays due to ramp closures. Aircraft delays incurred from lightning-induced ramp closures is investigated by means of air traffic simulations. These simulations enable exploration of opportunities to minimize operational inefficiencies while maintaining outdoor personnel safety. Monetary valuation of the safety risks and air traffic delays allows balancing personnel safety and operational efficiency from an economic perspective. Results will be presented from exploring an economic balance framework and examining impact and cost tradeoffs in search of a "most effective" lightning ramp management operation that balances both efficiency and safety.

This research is supported by the Federal Aviation Administration (FAA). The views expressed are those of the authors and do not necessarily represent the official policy or position of the FAA.

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MET-GATE: the future European MET information exchange system

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Speaker: Stéphanie DESBIOS

Following on from the successful developments in SESAR's WP11.02, the INEA funded project named 'European MET Information Exchange (MET-GATE)' commences a staged approach to the implementation of this 'new way' of intelligently accessing MET information. The MET-GATE will be the 'one-stop-shop' for MET information ensuring the SWIM compliance. It is an access portal enhanced with several 'smart' functionalities. It will allow all European (ECAC wide) producers of MET information to publish, and for all (ECAC wide) stakeholders to access existing and new MET services; and if deployed in conjunction with the accompanying MET forecast (icing, turbulence and convection), will deliver a common, harmonised and consistent MET forecast information service to all stakeholders. High resolution wind, temperature and humidity forecasts for trajectory planning and management could also be included for the ECAC region via MET-GATE at a later stage and accordingly to national and European users' requirements.

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A Novel Approach to Meteorological Warning Systems

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sêaker: Pavel A Munshi

Several meteorological events around the Planet cause enormous damage to life and the global economy, in spite of existing powerful forecast and warning systems. One of the significant reasons lies in the general understanding of the impacts of these events and disaster management. In addition, advantages of multi hazard impact-based (MHIB) forecasting is well known as outlined by the World Meteorological Organization. Though there are several successful implementations of the approach such as the National Meteorological and Hydrological Service (NMHS) and the progression from simple forecasts to (MHIB) systems has been appreciatited by the community. But significant challenges remain in the implementation, awareness, collaboration, applicability, etc. of such systems not only in developing but even in developed countries. One of the challenges posed is in the deployment and execution in cases where data availability and quality are also questionable. Not only that, the communication gap even among scientists, researchers, agencies, organizations and the general public creates more problems. Moreover, many such systems are quite expensive and are a time-consuming exercise for implementation in developing countries.

To solve all these problems, there is an absolute need not only to apply an all-encompassing approach for observation, modelling and prediction but to develop a multi-disciplinary innovative system which has high scalability, applicability, and effectiveness in communication in all.

Impact Based Forecasting coupled with new machine learning (ML) algorithms has significant advantages in the development of a warning system. This communication describes a schematic algorithm which is open source, based on new advanced cloud- infrastructure and (ML) techniques which have real potential and not restricted to specific regions. Consideration is also taken to essential data management and interpretation from observational and modelling thrusts. The open-source approach will benefit one and all, including the applicability and narrowing the communication gap. To demonstrate the real world potential: two cases, specifically a hurricane and a hypothetical storm surge are studied on. This system is being developed to be deployed in a web-system as well as mobile application with several considerations of regional problems. This system is robust and can serve as a better warning model to aeronautical meteorology and in the entire domain of hazard management and warning systems alike.

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The role of satellite imagery in the verification of terminal aerodrome forecasts (tafs) in the Uganda National Meteorological Authority (UNMA)

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Speaker: Yusuf Nsubuga

The weather satellite is a type of satellite that is primarily used to monitor the weather and climate of the Earth. Satellites can be polar orbiting, covering the entire Earth asynchronously, or geostationary, hovering over the same spot on the equator. They can be owned by governments, institutions or businesses.

In the Uganda National Meteorological Authority (UNMA), the geo-stationary satellites are used since the country lies astride the equator. These satellites are owned by European Organisation for the Exploitation of Meteorological Satellites (EUMETSAT), which comprises thirty (30) European Member States.

The images of the Earth that are collected by the satellites include meteorological measurements such as cloud cover, cloud motion vector, precipitation as well as vertical profiles of temperature and humidity. At the National Meteorological Centre (NMC) at Entebbe International Airport, the satellite images are displayed using the Synergie System of the Monitoring for Environment and Security in Africa (MESA) programme.

In Uganda, Terminal Aerodrome Forecasts (TAFs) are made using meteograms but because a single satellite image provides a wealth of information for the forecasters, the satellite imagery helps the forecasters to verify the TAFs.

The verification of the TAFS is important in ensuring quality service delivery.

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Meteorological information delivery services definition by EUROCAE WG-76

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Speaker: Boris Resnick

European Organization for Civil Aviation Equipment (EUROCAE) Working Group-76 is tasked to analyze, identify and standardize European view of AIS/MET Datalink Services, with a focus on meteorological information delivery.
Now WG-76 is developing a set of seventeen standardized Services. Proposed WG-76 Services comprise aeronautical, meteorological and mixed information services.
The meteorological services are as following:

1. Winds and Temperatures aloft will provide flight-related detailed 4D wind and temperature information (forecast only) during flight preparation for trajectory change anticipation or en-route for crew awareness or re-routing management.
2. Wind-Temp data for Flight Management will provide flight-related detailed wind and temperature data for automated entry into the Flight Management Systems for strategic re-routing only.
3. Aerodrome Weather will provide airspace user with updated information about actual and forecast atmospheric conditions (wind, pressure, QNH and QFE, dew point, visibility, clouds, significant phenomena) in flight and during take-off preparation.
4. Hazardous Weather will provide significant en-route weather and other phenomena in the atmosphere that may have an impact on the flight safety (clear air turbulence, mountain waves, convective areas, icing areas, dust and sand storms, cyclones, volcanic ash, space weather, radioactive clouds).
5. Weather Phenomena in Critical Flight Phases will provide rapid updated information on meteorological phenomena that may have a direct significant impact on the flight safety during parts of the flight that occur on the aerodrome and in its vicinity (low level wind shears, microbursts, wake vortex warnings).
6. Atmospheric Information will provide flight-related detailed forecasts on atmospheric conditions (jetstreams, low level and surface pressure, precipitation, tropopause and tropopause temperature); from the flight preparation after crew has embarked until take-off, and during all flight phases.
7. Weather Imagery will provide MET products derived from raw observed information coming from weather imagery (satellite: visible, infrared or composite; radar mosaic; lightning).
8. Winter Conditions will provide mixed AIS/MET information associated with winter operations (actual and forecasted heavy snowstorms, freezing rain, runway breaking action, breaking conditions, snowbanks size, de-icing procedures, taxiway restrictions).

Used cases and corresponding detailed service definitions are presented.

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Smartening aviation meteorology

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Speaker : Christian

The overall objectives of airport operations are to operate on a maximum capacity limit by maintaining a high level of safety. Awareness of any disruptive occurrences is of enormous significance to manage air traffic in an efficient and reliable manner. Weather related interferences play a fundamental role for almost all major airports all over the world. Therefore a lot of research has been done in the past and is currently ongoing to develop and provide improved dedicated meteorological information's and an adequate provision and visualization for the decision making process. In Europe, SESAR 1 and the successor SESAR 2020 program aimed at modernizing the Air Traffic Management (ATM). Selex ES developed a smart system solution that generates and visualizes tailored and fit for purpose MET products in a service oriented way to improve the situational awareness of weather hazards relevant to the airport and its surrounding aerodrome. In contrast to conventional weather observing systems, the new smart system (Selex SmartWx) is capable to provide high accurate, reliable and enhanced weather information based on sensor synergies as well as color-coded MET alerts and warnings of observations, nowcast and forecasts. The smart weather system is exceedingly flexible in terms of MET sensor input sources and serves a user friendly and highly configurable display tool based on state of the art and platform-independent web-based technology. Thanks to a smart service-oriented architecture implementation ensures the interoperability to the System Wide Information Management (SWIM) for an easy integration into existing and new airport system infrastructures. Furthermore SmartWx is easily adoptable to other MET applications as well as to cope with multiple airports. The current status and future capabilities of SmartWx will be outlined and discussed.

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TBO-Met (Meteorological Uncertainty Management for Trajectory Based Operations), funded by A SESAR H2020 Exploratory Research Project

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Speaker: Juan Simarro Grande

In TBO-Met project the problem of analyzing and quantifying the effects of meteorological uncertainty in Trajectory Based Operations is addressed. In particular, two problems are considered: 1) trajectory planning and 2) sector demand analysis, both at the pre-tactical level (up to three hours before departure) and tactical level (during the flight). In each problem two types of meteorological uncertainty are considered: wind uncertainty and convective zones (including individual storm cells). Weather predictions will be based on Ensemble Prediction Systems and Nowcasts. At the trajectory scale, the main objective is to assess and improve the predictability of efficient 4D trajectories when weather uncertainty is taken into account. To reach this goal, a methodology based on the use of stochastic optimal control algorithms will be explored for robust trajectory planning at the pre-tactical level. At the tactical level, various tactics will be investigated to avoid storms by using a Monte-Carlo method. At the sector scale, the main objective is to analyze the impact of the previously developed trajectory planning on sector demand. To achieve this objective, a methodology will be developed to measure the uncertainty of sector demand (probabilistic sector loading) based on the uncertainty of the individual trajectories. This analysis will also provide an understanding of how weather uncertainty propagates from the trajectory scale to the sector scale. All solutions proposed in this project will be evaluated and assessed using an advanced air traffic simulator.

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Forecast and Warning System of Aviation Meteorology on MICAPS

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Speaker: Surong Zhao

MICAPS (the Meteorological Information Comprehensive Analysis and Processing System) is widely used in meteorological department in China. Almost all kinds of meteorological data can be specified by MICAPS, but aeronautical Meteorological Data. Fortunately, it has an open architecture. So the Forecast and Warning System of Aviation Meteorology (AMFWS) is developed on MICPAS. AMFWS can display the data of WAFS. It has two kinds of data searching modes: chart searching , OPMET searching. All kinds of OPMET data are decoded and saved as meteorological element files. User can easily analyse these data. On the other hand, This system adds two new modules. One can be used making message, such as TAF. The other one is making Prog Charts. Therefore in the aviation meteorological services AMFWS can play a significant role.

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Posters relating to Session 3

HABOOB impacting air traffic operations: case study of khartoum international airport

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Khartoum state is prone to the Haboob, as it adjacent the Greater Sahara Desert. The frequency of the Haboob occurrence is exploded, which affects the air traffic operations. Therefore, this study analyzed the meteorological conditions that trigger the Haboob and the areas affected in the Khartoum State. The recent case of Haboob occurred in the 1st of June 2017 at 1530UTC (1830 local time) was analyzed at the surface and upper air levels by using both synoptic observations and Global Data Assimilation System (GDAS) model output with 0.5-degree resolution. The horizontal visibility dropped to null and wind gust reached 25KTs at Khartoum International Airport after 30 minutes from the presence of CB in the southeast direction. Visibility deterioration lasted for one and a half hour. Huge amount of dust particles lifted upward and deposited in Khartoum state which hosts the two international airports. The backward trajectory revealed that, the source of the Haboob was from the surrounding areas and the destination was the entire state. It is evident that, the Haboob disturbed the air traffic operations for over two hours. The current airports are susceptible to the Haboob during the summer season that causes delays and cancellations of scheduled flights especially during the afternoons and nights. The increased Haboob events are attributed to the climate change impacts. The outcomes of this study can be used to determine the suitable alternative airports and to alert the aviation industry for the occurrence of Haboob in advance.

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Airframe Icing as an effect of Tropopause level rise and ways to combat with it

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Recently, the global-mean pressure at the tropopause has decreased 2.16hPa/decade, which gives clear indication of the increase in the height of the level of the troposphere. We know that the atmospheric pressure depends on the atmospheric temperature, which in turn varies with latitude; hence varying the tropopause height latitudinally as well as seasonally. Thus, both warming the troposphere or cooling the stratosphere lead to the increment of the height of the troposphere and these can result from five different climate forcings; two natural and three human-related. The two natural forcings are changes in solar radiation and volcanic aerosols. The anthropogenic forcings are the direct scattering effects of sulphate aerosols and ozone along with the well-mixed greenhouse gases. Mainly, changes in solar radiation occur seasonally. Volcanic aerosols that get injected into the stratosphere during massive eruptions absorb incoming solar radiation, thus warming the stratosphere and cooling the troposphere. The sulphate aerosols produced by burning fossil fuels also cool the troposphere thus lowering the tropopause. Thus, these three factors either have negligible or negative effect on tropopause height increase. The chlorofluorocarbons deplete stratospheric ozone, thereby cooling the stratosphere. Well-mixed greenhouse gases, such as the carbon dioxide produced from burning fossil fuels, simultaneously warm the troposphere and cool the stratosphere. Hence, these two forcings are primarily responsible for raising the tropopause level. Rise of the tropopause is one of the major reasons behind high-altitude icing. At mid-troposphere, temperatures usually remain within −4 and −14 °C and only a limited fraction of suitable aerosols is available to act as cloud condensation nuclei; thus, cooling the large amount of available water vapour and favouring the formation of large supercooled droplets. But near tropopause, where temperatures are below −50 °C, ingestion of a high density of iccles takes place in the vicinity of convective cloud tops with ice contents in excess of 5g/m3. All these lead to an upward extension of the upper limit of icing layers; thus, increasing chances of airframe icing, a problem for general aviation and more specifically, commuter aviation where rudimentary anti-icing systems are employed, the most common being pneumatic de-icing boots, which run chemically. Airframe icing can modify the airflow pattern around wings and propeller blades leading to loss of lift, increase in drag, altered pressure distribution around flight control surfaces such as ailerons and elevators and cause shift in the airfoil centre of pressure leading to longitudinal instability. In certain cases, blockage of pitot tubes and static vents can also take place giving rise to erroneous readings in pressure instruments such as altimeters, airspeed indicators and vertical speed indicators. Limited engine power is another major hindrance to overcome airframe icing in aeronautics, for which modern lean-burn aviation engines are used widely. But, these engines contribute more to fossil fuel combustion and thus to positive greenhouse forcing, thereby contributing more to the raising of tropopause level and airframe icing. So, keeping the environmental sustainability in mind, switching to solar-powered electric aircrafts is a better alternative. Solar cells can be used to power the electric motors, communications, electronic systems and avionics. A backup lithium battery system can be employed for flight operations under dark conditions. For commercial purpose, more electric engines equipped with generators can be integrated into the aircraft engine such that maintenance costs can be lowered and overall reliability may increase.

Keywords: Rise in tropopause height, Airframe icing, Positive greenhouse forcing, Solar-powered electric aircraft

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Impact of Fast and Large-scale infrastructural changes in and around Delhi's IGI Airport in 1960-2017 caused high warming trend and Alarming Change in temperature pattern at daily to decadal scale

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In these days of commercialization and public demands for integrated facilities at one location, large pool of lands occupied by airport at most city corners at outskirts are no more alone restricted to cater alone aviation services. These airports have been re- developed them into integrated high urban centers where aviation operations, mega terminals with hotels, shopping centres/malls with various leisure's/sports facilities have come up and thus they have been in wide way of large-scale urbanization and re-developed. The most drastic change has been that, in parallel, surrounding these airport, large pool of residential and other facilities have been come up. So most of them which were often classify as green landscapes at country side at far rural pockets with least or limited public access now have wide concrete structure, multi-transport system, with higher local pollution of GHG as higher is the population penetration as users access by road ways at airport link, besides substantial increase in number of flights producing higher carbon foot prints at airport. Such drastic change of land use changes and increase of pollutions at a sub-urban end meteorologically in longer terms also changes its surface and boundary layer and radiation process and hence likely to cause local heat island effect which would have been the case for high urbanization in major city side development instead.

Delhi has two airports one older SFD airport located at heart of city since late 1900s and the newer one IGIA since 1950s at southwest side a far 12-15km radial distance. Both have IMD Synop observatory of class record of data of longer period daily 3-hourly intervals. The older airport at city are still surrounded by all Govt acquired and VIP areas where only Govt offices and residential have been there, as it has been highly restricted to urbanized during post 1990 period of boom in population and hence it may be presumed here that later pocket have barred from any high urbanization and hardly any bigger new buildings or urban pockets might have been added in these areas. However IGIA areas, though it was outskirt, but last 15-years, have incurred highly urbanized path as to meet both airport commercialization, new aviation infrastructure like T3-8th largest in world, a RWY-Asia longest one etc., and new residential vast campus and wide roads have come up in demand of large-public.

In this paper, we extensively have studied air temp at day to day, min, max, monthly averages, etc of both airports of Delhi including how are their differences of temp are now in 2010s in compared to those were in 1960's in each month or each day in summer, winter, monsoon season or decade wise and also their longer period trends during 1960-2010. It finds average annual temp at Airport side of Delhi during 1969-2011 has warmed up by 1.4. degC while Safderjung airport, the main city station data does not shows any warming during the period. As was the case with high urbanization of other part of the word's city temp, it warmed very fast at night with monthly men air temp shows in last 40-years the min temp in some season and month have increased to upto 1.5 to 2 DegC, an alarming one with City data not showing much trend. The crucial finding in this study which is most alarming has been the creation of heat island effect at suburban rather than main city(Safderjung-SFD) as the average March, April and May and June month's(All summer months) min temp during 1969-1975 used to record a 2degC cooler to that of IGI Airport, Palam for same period and months, but toward 2011, it became 0.8-2degC, warmer, a trend of 2-3.5degC reversal of such temp pattern. The same is also findings of Sept to Dec and Jan-Feb months. It notes that the heat island effect at such fast urbanized growth at latter western part of city are really alarming and hence needs special green policy and a type of planning where at least at airport which has been urbanized at fast rate may accommodate roof top gardening or covering of some all concrete cover areas to be by other less heat trapping materials as per green codes.

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Relating Large-scale Indo-Gangetic dense Fog occurrences across South Asian Airports to Flight diversion/safety for 2008-2017, New safety challenges of ATC-airlines-Airport during LVP, Development and Implementation of new Aviation operational CDM processes, management and regulation

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The great Indo-Gangetic Plain(IGP) lies in northern part of south Asia and runs parallel just at south of Himalayan also known as the Indus-Ganga Plain is a 255 million hectare fertile plain encompassing most of northern and eastern India, the eastern parts of Pakistan, and virtually all of Bangladesh and houses 500milion population. It holds many major airports of south Asia across it as encompasses a number of large urban areas with Lahore at west, then Amritsar, Ludhiana, Jaipur, Chandigarh, Delhi, Lucknow, Allahabad, Varanasi, Patna, Gaya, Kolkata, Dhaka, Guwhati etc.. Study finds Due to its specific topographical extent, high moisture supply and green coverage, large-scale semi-permanent subsidence/radiational inversions with low speed surface winds and low temp, higher pollutions contents prevailing in each winter of Nov-Feb, IGP suffers a lot from frequent spells of occurrences of high duration dense fog and smog events at both meso-scale as well as large-scale, with such events often last upto 10-20 days un-interruptedly at a row and 8-12 hours daily having visibility remaining struck to 0-50m at most of these airports which force LVP implementation frequently or finally closure of the airports for longer hours (Jenamani, 2009, www.currentscience.ac.in/Volumes/100/04/0491.pdf, Mausam 2012a and b , 2017, www.currentscience.ac.in/Volumes/112/04/0667.pdf). These Studies also shows both temporally and spatially, such fog events may be the fastest in formation, largest in areas and longest in duration, if compared to any other fog areas of the world and, so also in terms of magnitude of its severe impact as it spreads over such world's mostly densely populated region. Frequencies and duration of fog at Delhi at <1000m and <200m since 1960s till 2015s finds both general and dense fog duration have increased by 30-40 and 15 times respectively which ash been quite alarming for aviation operation.

In the present study, we have analyzed and classified spatial extent, temporal aspects of fog occurrences in terms of intensity and durations, using satellite, airport RVR and visibility data of the region with data since 1990s, 2000s data and 1960s respectively and their impact on passenger discomfort and aviation safety, flight diversion and cancellations etc., with later data available since 2005. We have also reviewed what processed critical fog information that MWO Delhi providing at real time and its meso- climatic features as post analysis of fog data at RWY-wise to regional wise for airports of Delhi FIR, for major Indian airports like Delhi, Amritsar, Jaipur, Lucknow, Varansi, etc using data of 1981-2014 to various aviation stake holders and regulator and coordinated with them to publish a final Govt mandate low visibility operation policy document in April 2014 http://pib.nic.in/newsite/PrintRelease.aspx?relid=104918. We analyzed how we implemented it by Dec 2014, that started delivering results of its main objective in last three fog seasons 2014-17 by significantly reducing flight diversion from 140-217 flights to just 12 flights and increasing the safety.

Present study finds types of challenges and safety issues and weather hazards, those all aviators have been faced during their flight operations in such large-scale thick fog in such vast region depend what type of flights they are e.g. Helicopter, ATR, smaller aircrafts, bigger aircrafts and whether operating in VFR or IFR or the aircraft and crew those in aircraft are CAT-IIIB compliances or their operating airports are CAT-IIIB compliances, whether Airport ahs RVR and if it has whether it is functional. Study also finds IGP Large-scale Fog blankets affected aviation in many ways in case vis reaches 0-200m e.g. flight take off at concern airport delay/cancelled, incoming flight gets diverted to far airports and needs much higher reserve fuel compared to its summer storms related diversion from same airport as the fog diverted aircrafts form one of its fog affected airport does not get suitable airports to land nearby as would be the case with localized storm related one, as all these latter airports are closed either simultaneously under same fog blanket or much before to former one, Airport like IGIA even has capacity to operate RVR upto 50m in CAT-IIB at two RWY, its overall hourly capacity recue to as low 70% delaying departure to hours, Terminals overcrowded as flight

operation cancelled and passengers are kept in waiting and suffering increased for those who are boarded flight at late night, boarding gates closed, but sudden dense fog hit RWY, RVR<50M and thus wait for hours to take off, in case spell last for weeks it creates a huge backlog and all spill over as flight not moving in or out to those airports. Also, what bad experiences passengers face in case flight diverted and why its return also delayed. Besides such direct impact, Indo-Gangetic Fog are also hazardous for flying aircraft in case any flight coming to Delhi has reached but finding lower than its minima, if it holds up waiting to improve will be further disastrous as IGP fog never easily lift and by the time it decides for diversion it will have very low fuel to reach to a suitable diversionary airport.

We have discussed one serious case study of 5-6 Jan 2014 using 30-minute vis data and 10-15 second RVR data and data of its severe impact on flight operation in the region when by 1500UTC all airports in the region has vis of 0-100m .By 1400 UTC of 5 Jan 2014 , the IGIA vis/all 13 RVR values fallen below 100m, one of the record early dense fog formation, when all domestic flights arrival is at peak, so 59 arrivals to Delhi were diverted to alternate aerodromes to Jaipur by mid night, which is the most preferred alternate for Delhi among airlines, as the latter airport was no parking space and many diverted flights were running low on fuel also in search diversionary airports as fog continued till late morning. One non CAT-III flight faced accident by crash landing at Jaipur in lower minima and slipped out of RWY, passengers got hurt only luckily.

In developmental aspects, we find with increasing traffic and passenger growth across the region, a lot of progress has been made in 2010-17 to get much respite from such killer fog like airport infrastructural facilities at airside covering CNS, ILS, ATS and Met monitoring and early warning systems and implementation of many new regulations for smooth operation. The total RVR was just 3 in Jan 2008 at IGIA which increased to 18 in number-a largest in the world in Dec 2016 and in the whole Delhi FIR it increased from 3 to 33 RVR. As LVTO started at IGIA from Dec 2011, we have analyzed how it has helped in reducing the cancellation from 1000s in 2010 to 100s in 2015-16, irrespective both have high fog durations. By Dec 2016, a historic progress to fight fog has been made as three more airports of Delhi region i.e. Lucknow, Amrtisar and Jaipur have been equipped with all CAT-III ILS operation further gearing the regional efforts to ensure flight lands at dense fog upto RVR 50m.

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Effects of Projected Temperature Change on Aviation in Africa

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Climate change is projected to increase mean temperatures at all airports and to significantly increase the frequency and severity of extreme heat events at some. These changes will negatively affect aircraft performance, leading to increased weight restrictions, especially at airports with short runways and little room to expand. This study models projected future weight restrictions across a fleet of commercial aircraft with different takeoff weights operating at a variety of airports in Africa. The daily temperature projections from the CMIP5 models under the RCP 4.5 and RCP 8.5 emissions scenarios are used to calculate required hourly weight restriction. An average of 10–30% of annual flights departing at the time of daily maximum temperature may require some weight restriction below their maximum takeoff weights, with mean restrictions ranging from 0.5 to 4% of total aircraft payload and fuel capacity by mid- to late century. Both mid-sized and large aircraft are affected, and airports with short runways and high temperatures, or those at high elevations, will see the largest impacts. Weight restriction may impose a non-trivial cost on airlines and impact aviation operations. Planning for changes in extreme temperature and adequate adaptation may be required in aircraft design, airline schedules, and/or runway lengths will help the aviation industry to reduce its vulnerability to climate change.

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Spatio-Temporal Analysis of Heavy Rainfall (HRF) Events in a Changing Atmospheric Environment over Some Cities in Nigeria

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In this study, attempts to define the threshold rainfall amount that qualifies a 24-hour rainfall event to be a heavy or extreme rainfall event over each of the cities studied were made using the value associated with a specific daily percentile rainfall value. This was carried out using sets of daily rainfall data that varied from 30 to 40years. Spearman's rank correlation, regression and trend analyses, percentages occurrence (frequency) and contribution (intensity) were calculated out on the data. There is evidence of temporal variability on the seasonal and inter-seasonal analyses, such that out of 37 cities studied, 26 cities recorded an increase in the percentage occurrence of HRF from 1971 – 2014, 9 cities recorded a decrease while 2 cities remained relatively unchanged with time while 25, 9 and 3 cities out of the 37 cities showed positive, negative and unchanged trends respectively in the occurrence of extreme rainfall events. Furthermore, Intra-seasonal study showed that only Ikeja have the average peak of the frequency of occurrence of HRF in June, majority of the southern cities have their maximum heavy rainfall (HRF) occurrence in September while all the northern cities have theirs in August. Generally, the average frequency of occurrence of HRF and ERF showed double peaks in July and September in both cases, but with the highest peak occurring in September and July in the cases of HRF and ERF respectively. The northern cities showed single peaks in August in both cases of HRF and ERF. However, spatial analyses showed that the HRF threshold values increase with longitude as we move from west to east but was observed to be decreasing with latitude as we move from south to north, which is in line with the spatial distribution of moisture across Nigeria. Having quantified the rainfall in Nigeria as a distribution, forecasters now have additional and valuable information on rainfall thresholds that can result in significant flooding (flash flooding), disrupt construction works and even overwhelm water reservoirs or dams.

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Impact of extreme weather events and coastal inundations in India on Aviation industry: Case study of incessant rainfall activity in and around Chennai city during November 2015

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Aviation industry is most vulnerable to extreme weather events. Increasing trend in such events poses multifarious challenges in providing sustained aviation meteorological services. In India, extreme weather events such as heavy rainfall and resulting floods, poor visibility owing to dense fog, prolonged heat wave conditions, passage of tropical cyclones over North Indian Ocean, turbulence, wind shear and lightning associated with violent thunderstorms are known to have direct bearing on aviation industry in terms of reduction in take-off weight, cancellation or re-routing of flights and closure of airports. This ultimately results in huge economic loss to the aviation industry.

According to IPCC Fifth Assessment Report, East, South, and Southeast Asia would experience increase in extreme rainfall events related to the monsoon. More than 85% of CMIP5 models show an increase in mean precipitation in the East Asian summer monsoons, while more than 95% of models project an increase in heavy rainfall events. The increasing trend in extreme rainfall events could be ascribed to enhanced moisture content or preponderance of warmer SSTs in the tropical Indian Ocean, interaction of mid-latitude westerlies and monsoon current and passage of easterly waves. Such extreme rainfall events often lead to floods. The risk of flood and associated human and material losses are heavily concentrated in India, Bangladesh, and China.

Presently, city of Chennai in India ranks 14th among top 20 cities of the world with greatest rate of increase in population exposed to extreme sea levels. It is projected to see more than 300% increase in exposure by 2070s. Many top Asian cities in terms of population exposure would be vulnerable to coastal flooding by 2070s. This projected climate change scenario accentuates need to address the issue of providing sustained aviation meteorological services.

From 1st November 2015 to 4th December 2015, the city of Chennai was battered by incessant heavy rainfall owing to passage of four tropical disturbances resulting in flood. Extreme rainfall was recorded at many south peninsular stations during this period. The deluge culminated in closure of Chennai airport for operations resulting in enormous loss of life and property. November 2015 was the rainiest month for Northeast Monsoon Region (NMR) and warmest November for the Indian region since 1901.

In this paper, we present analyses of Chennai rainfall event from the perspective of aviation meteorological services based on modern ground and satellite based observational systems in conjunction with reanalyses dataset. The thermodynamical, dynamical and microphysical perspective of these events resulting in inundation owing to interaction between wave-like tropical disturbances in moist zonal flow which moved from east to west and dry mid tropospheric sub-tropical westerly trough with anomalous southward penetration have been presented. The interaction between two wind regimes culminated in increased lapse rate, sustained rising motion, high cloud top and deep localized convective systems.

Key words: Extreme Rainfall, Coastal Flooding, Tropical Disturbances, Aviation Industry.

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6 - 10 November 2017
Centre International de Conférences - Météo-France - Toulouse - France

The effect of el Niño/la Niña on the temperature and rainfall fluctuation at donmuang airport

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In this research we study the effect of El Nino/La Nina on the temperature and rainfall fluctuation at Donmuang airport for a period of 60 years from 1951 to 2010. The results show that these natural cycles have an effect on temperature and rainfall amount at Donmuang airport. Positive fluctuation from the average temperatures are usually correlated with El Nino cycles while negative temperatures are usually correlated to La Nina cycles. The greatest fluctuation in positive temperature is nearly 40C in the year 1957 during the El Nino cycle. The greatest fluctuation in negative temperature is more than -40C during the 1975-1976 La Nina cycle. La Nina phases tend to have a stronger effect on temperature than El Nino phases. As opposite to the temperature, positive rainfall amounts are usually correlated with La Nina cycles while negative rainfall amounts are usually correlated to El Nino cycles. When we compare the effect on temperatures and rainfall amounts from the present 2009-2011 El Nino/La Nina cycle with the previous three cycles (1973, 1983 and 1998), the effects from the present cycle seems to be following a similar path to the previous cycles. For the future weather forecasting, it will be better if these effects are added into the process.