



## Global and Regional Ensemble Prediction Systems of NCMRWF

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# NWP Model



Numerical Weather Prediction (NWP) models are essential tools for forecasting Weather. A numerical model is a set of computer programs designed to simulate a real system; in our case weather.

Equations based on laws of physics are integrated forward in time to simulate changes in the atmosphere.



## 1. Initial Conditions



# The more accurate the estimation of the *Initial Conditions*, the better is the quality of forecasts.





# 2. Governing Equations



- 3 equations for accelerations of 3-d wind ( $\vec{F} = m \vec{a}$ )
- Conservation of mass
  - 1 equation for conservation of air (mass continuity)
  - 1 equation for conservation of water
- Conservation of energy
  - 1 equation for the first law of thermodynamics
- Relationship among p, V, and T
  - 1 equation of state (ideal gas law)
- Mathematically, these equations are expressed as a system of nonlinear partial differential equations.



## 3. Numerical Procedures







## 4. Boundary Conditions





#### No need for lateral boundary conditions in global models.



# 5. Physical Processes



- •Small scale processes are not resolved by large scale models, because they are **sub-grid**.
- •The **effect** of the sub-grid processes on the large scale can only be represented statistically.
- •The procedure of expressing the effect of sub-grid processes is called **parameterization**.
- Radiation transfer
- Surface processes
- Vertical turbulent processes
- Clouds and large-scale condensation
- Cumulus convection





## 6. Model Output



#### Meteogram





## Uncertainties in NWP





#### Growth in forecast uncertainty is flow dependent





# Can we forecast the uncertainty in forecast?

**Ensemble prediction system (EPS)** provides a way of quantifying the uncertainty in forecasts using a stochastic dynamic prediction method

- Estimates the PDF of the initial state
- Follows a method for forecasting the evolution of this PDF
- Estimates the forecast PDF
- Makes a probabilistic forecast



# Why communicate forecast uncertainty



- 1. Useful for both forecast provider and the user
- 2. Assists people to make more effective decisions
- 3. Communicating uncertainty helps manage user expectations
- 4. Communicating uncertainty retains user confidence
- 5. Forecast uncertainty reflects the state of the science



## **Can we forecast the uncertainty in forecast?**



# **Ensemble prediction system (EPS)** provides a way of quantifying the uncertainty in forecasts

**Deterministic Forecast** 







- Ensemble mean can be used as a single deterministic forecast
- It provides an indication of the reliability of the forecast. Spread in the forecast is a measure of disagreement between the ensemble members
- It provides a quantitative basis for probabilistic forecasting.



## **NCMRWF Global Ensemble Prediction System** (NEPS-G)



**Horizontal resolution** 

:~12 km

No. of grid points

No. of vertical levels

No. of Ensemble members

IC Perturbation method

Surface Perturbations

**Physics Perturbation method** 

**Forecast length** 

- : 2048 x 1536
- :70

: 22

- : Ensemble Transform Kalman Filter (ETKF)
- : SST, Deep soil temperature and soil moisture perturbations
- : Stochastic physics (SKEB and Random Parameter schemes)
- **:** 10 days



## NCMRWF Regional Ensemble Prediction System (NEPS-R)



Horizontal resolution

Vertical levels

**Model Domain** 

**Ensemble size** 

**Initial Conditions (IC)** 

**Boundary Conditions** 

Convection

**Physics Perturbation** 

**Forecast length** 

: 4 km

- : 80 levels up to 38.5 km
- :  $62^{0} \text{ E} 106^{0} \text{ E}$  and  $6^{0} \text{ S} 41^{0} \text{ N}$
- : 12 (1 control + 11 perturbed)
- : IC perturbations generated by ETKF added to regional 4DVar analysis
- : From NEPS-G
- : Explicit
- : Random Parameter scheme
- : 3 days



# **EPS** Forecast Products



- 1. Mean and Spread Plots
- 2. Probability of Exceedence
- 3. Postage Stamp Maps
- 4. EPS gram
- 5. Ensemble Mean Track
- 6. TC Strike Probability
- 7. Storm following EPSgram



## Mean/Spread Plots

NEPS: 500 hPa Height (mt), Ensemble Mean (contour) and Spread (shaded) Ini:20210119 Day-4 Forecast Valid for 00Z23JAN2021



National Centre for Medium Range Weather Forecasting

![](_page_16_Picture_5.jpeg)

![](_page_17_Picture_0.jpeg)

## **Probability of Exceedence**

![](_page_17_Picture_2.jpeg)

50

30

![](_page_17_Figure_3.jpeg)

![](_page_18_Picture_0.jpeg)

## **Postage stamp maps**

NCMRWE

Ministry of Earth Sciences tl fcst

![](_page_18_Picture_4.jpeg)

Ens mem 4

![](_page_18_Figure_6.jpeg)

Ens mem 8

![](_page_18_Figure_8.jpeg)

![](_page_18_Picture_9.jpeg)

Ens mem 5

![](_page_18_Picture_11.jpeg)

Ens mem 9

![](_page_18_Picture_13.jpeg)

Ens mem 6

Ens mem 10

![](_page_18_Figure_15.jpeg)

Ens mem 7

Ens mem 11

![](_page_18_Picture_18.jpeg)

![](_page_19_Picture_0.jpeg)

### **Postage stamp maps**

![](_page_19_Picture_2.jpeg)

![](_page_19_Figure_3.jpeg)

![](_page_20_Picture_0.jpeg)

![](_page_20_Picture_1.jpeg)

![](_page_20_Picture_2.jpeg)

![](_page_20_Figure_3.jpeg)

![](_page_21_Picture_0.jpeg)

## Probability of Exceedance for daily minimum temperature

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(a) Tmin Fcst (b)Prob Tmin < 15°C 35N 30N · 30N 25N 20N 201 15N · 15N 10N 10 70E 80F 85F 95E -5-4-20 2 4 6 8 1012141618202224262830323436384042444648 (c)Prob Tmin < 10°C (d)Prob Tmin < 5°C 35N 35N 30N 30N 20N 20N 15N-10N 10N

National Centre for Medium Range Weather Forecasting

95E

70E

70E

80E

85E

95E

## Minimum Temperature departure from model climatology

![](_page_22_Picture_1.jpeg)

![](_page_22_Figure_2.jpeg)

![](_page_22_Figure_3.jpeg)

![](_page_23_Picture_0.jpeg)

#### Probabilistic visibility forecast of NEPS-R NEPS Day-1 Fcst valid for 20JAN2021

NCMRWA

![](_page_23_Figure_3.jpeg)

![](_page_23_Figure_4.jpeg)

![](_page_24_Picture_0.jpeg)

#### **Probabilistic lightning forecast of NEPS-R**

![](_page_24_Picture_2.jpeg)

Earth Sciences

![](_page_24_Figure_4.jpeg)

![](_page_25_Picture_0.jpeg)

Dhaka

20JAN

21 JAN

22JAN

#### **Forecast Products for Neighbouring Countries**

![](_page_25_Figure_2.jpeg)

Thimphu NEPS Forecast based on 19JAN2021 IC

![](_page_25_Figure_4.jpeg)

National Centre for Medium Range Weather Forecasting

28JAN

29JAN

![](_page_25_Picture_6.jpeg)

![](_page_26_Picture_0.jpeg)

#### Member tracks and strike probability

![](_page_26_Picture_2.jpeg)

![](_page_26_Figure_3.jpeg)

![](_page_27_Picture_0.jpeg)

#### **Storm Following EPSGRAM**

![](_page_27_Picture_2.jpeg)

NEPS-R\_4km\_500 ensemble: Tropical Cyclone storm-following meteogram

FANI (8.3N 87.4E) from 00UTC 29 April 2019 Number of ensemble members tracked Number of ensemble members tracked 10m wind maxima within 5 degree radius (kn) 10m wind maxima within 5 degree radius (kn) Mean sea level pressure minima (hPa) Mean sea level pressure minima (hPa) Mon 29 April 2019 Wed 01 May 2019 Wed 01 May 2019 Mon 29 April 2019 Tue 30 Tue 30 **Control** 

NEPS-G\_12km\_REGfani ensemble: Tropical Cyclone storm-following meteogram FANI (8.3N 87.4E) from 00UTC 29 April 2019

## **TIGGE – NCMRWF-EPS**

NCMRWA

The THORPEX Interactive Grand Global Ensemble (TIGGE) is an implementation of ensemble forecasting for global weather forecasting and is part of THORPEX, and international research programme established in 2003 by the World Meteorological Organization to accelerate improvements in the utility and accuracy of weather forecasts up to two weeks ahead.

ECMWF Spaces -	Q (? - Log
TIGGE	Pages / Home
	News
SPACE SHORTCUTS	Created by Richard Mladek, last modified on Dec 20, 2017
S2S	[2017][2016][2015][2014][2012][2011][2010][2008][2007][2006]
B TIGGE	
TIGGE-LAM	2017
🚯 UERRA	
S YOPP	20-12-2017 New model (NCMRWF, India) added to TIGGE archive New model outputs (NCMRWF, India) were added to TIGGE archive. The first starting date available thanks to the back-archiving is the 1st
PAGE TREE	of August 2017. Click here for more details.
News	

- Since 20-Dec-2017, NCMRWF started to contribute with real time update in TIGGE data portal web page along with back archival since 01-Aug-2017.
- In India, NCMRWF is the first research centre which contributes its real-time weather forecast data in the public domain for the purpose of research.

![](_page_29_Picture_0.jpeg)

Ministry of Earth Sciences

![](_page_29_Picture_2.jpeg)

![](_page_29_Picture_3.jpeg)