United Nations Educational, Scientific and Cultural Organization

International Oceanographic Data and Information Exchange

A regional ocean modeling system for short term prediction of ocean state

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Discovery and Use of Operational Ocean Data Products and Services

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Flanders State of the Art

Mathematical modeling

A mathematical model is a description of a system using mathematical concepts and language.

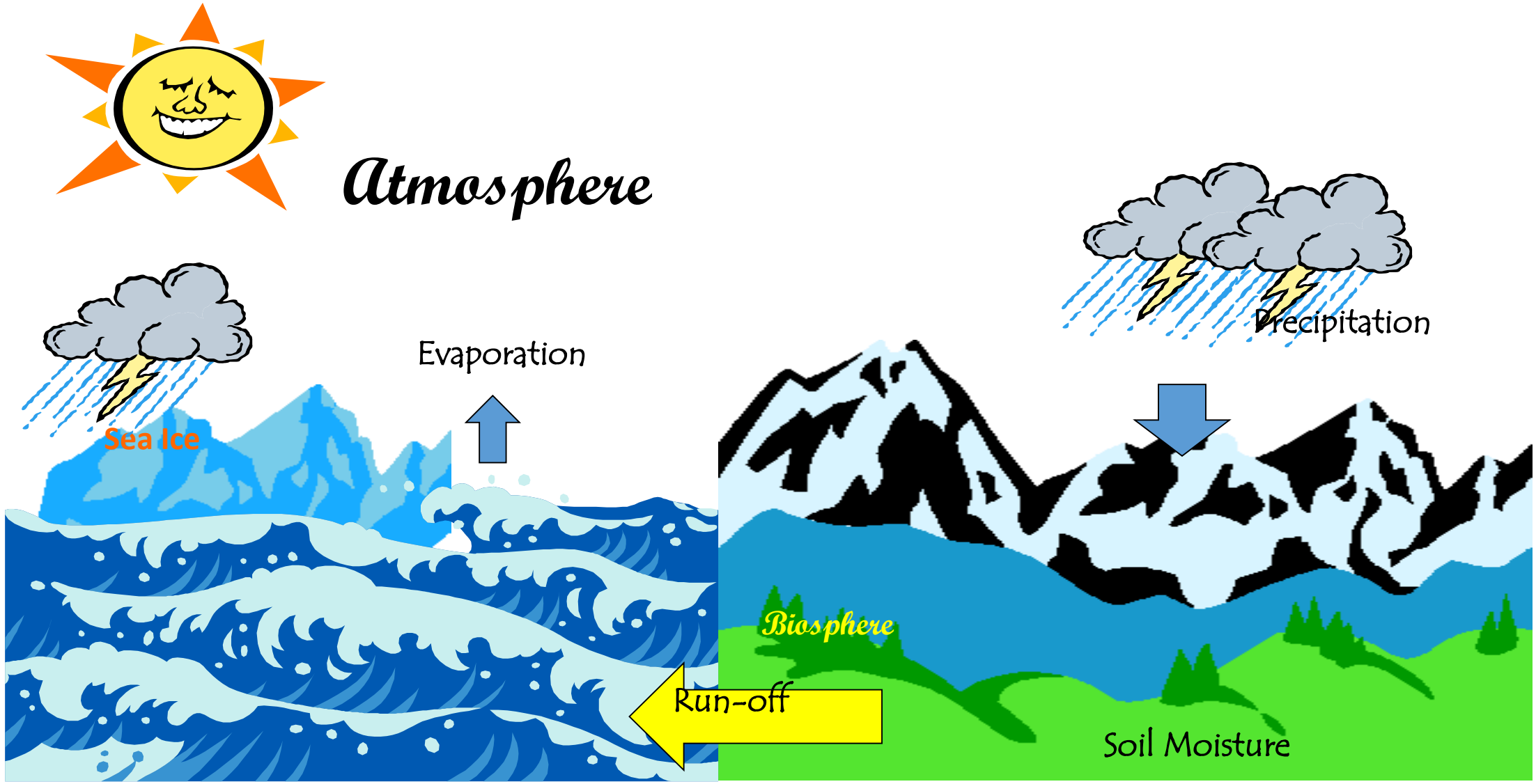
The process of developing a mathematical model is termed mathematical modeling.

Mathematical models are used in the natural sciences (such as physics, biology, earth science, chemistry) and engineering disciplines (such as computer science, electrical engineering), as well as in the social sciences (such as economics, psychology, sociology, political science).

A model may help to explain a system and to study the effects of different components, and to make predictions about behaviour.

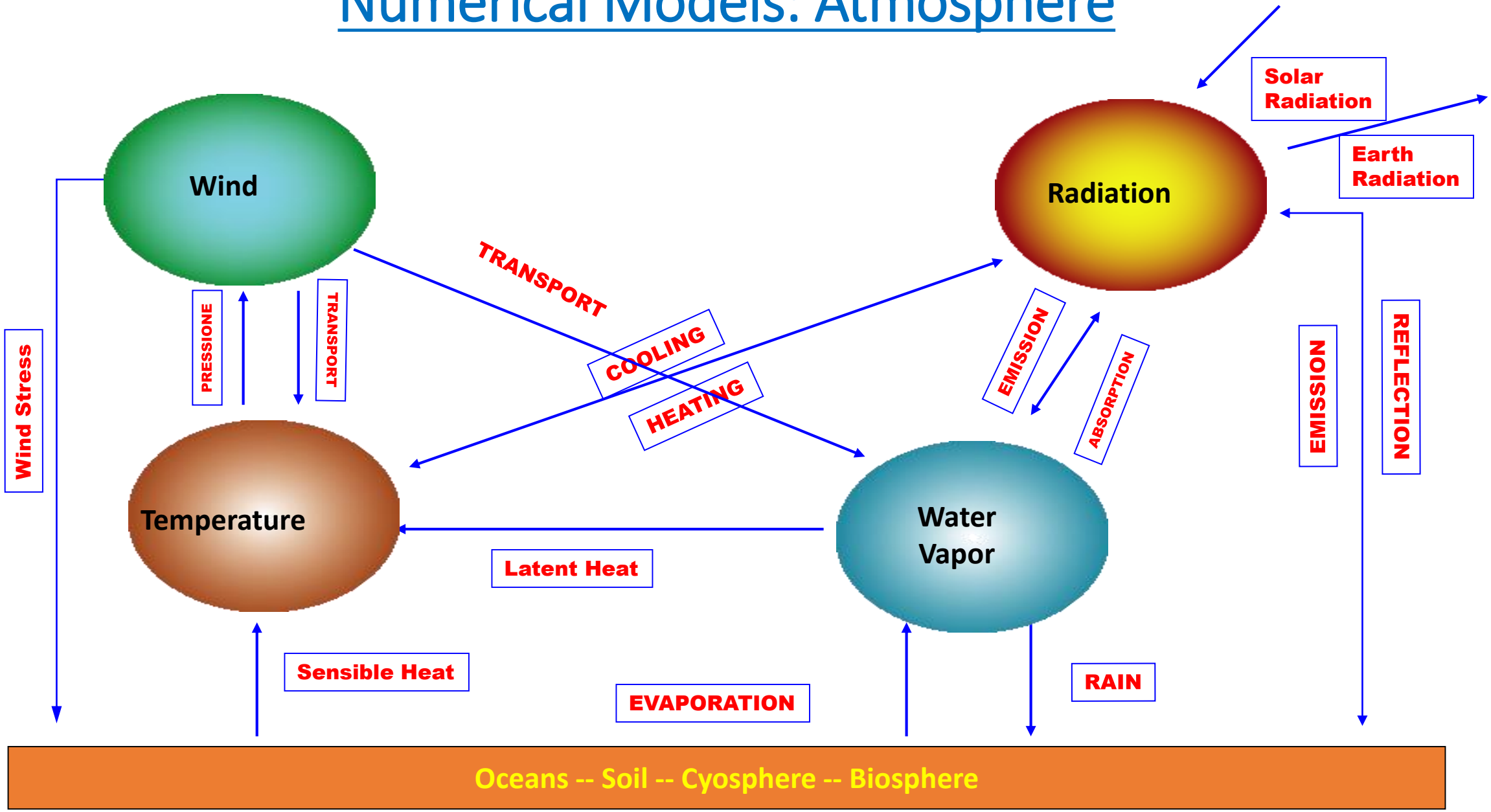
Source: Wikipedia

The Climate System



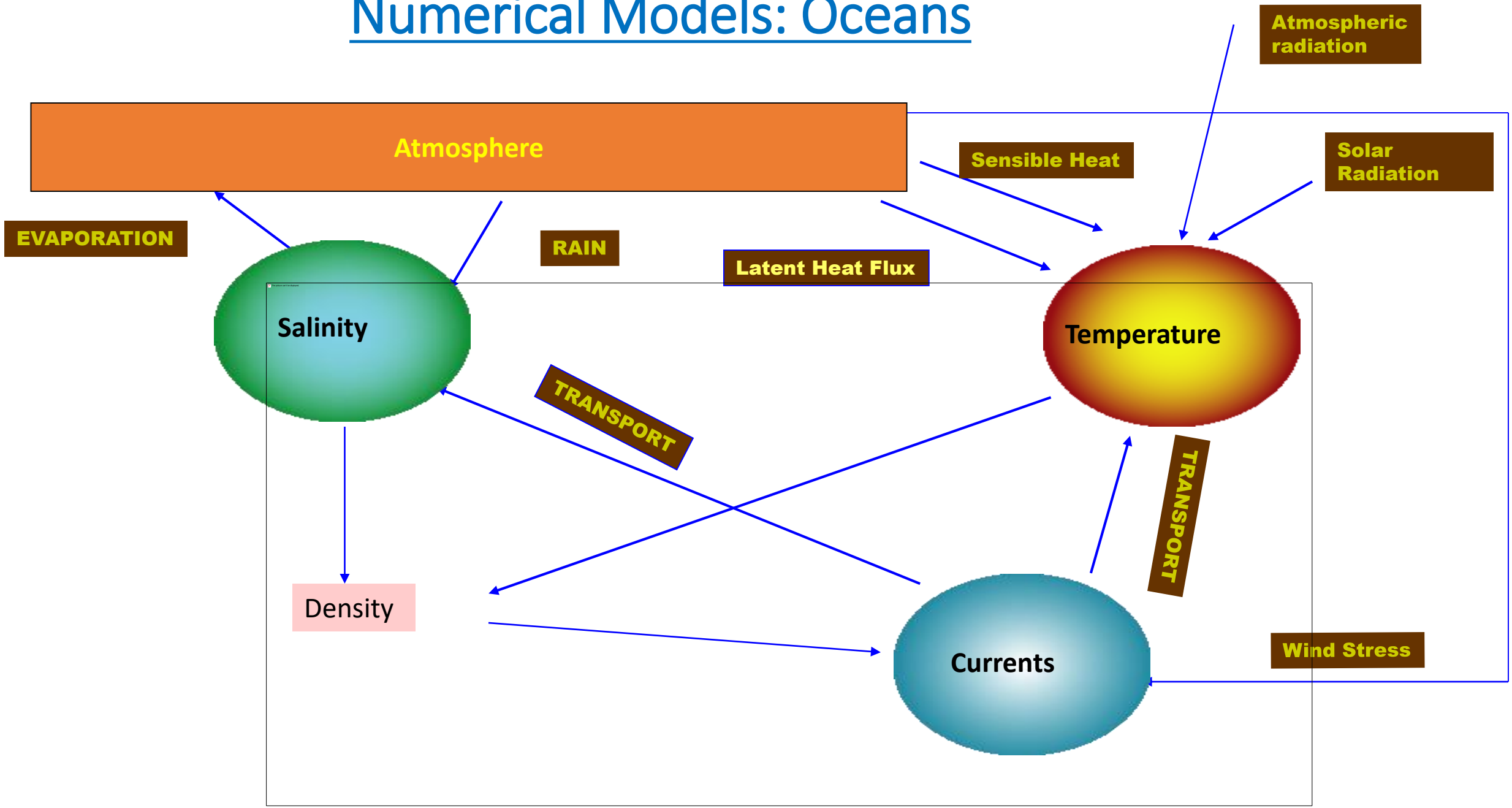
Source: Basics of numerical oceanic and coupled modelling by Antonio Navarra & Simon Mason.

Numerical Models: Atmosphere



Source: Basics of numerical oceanic and coupled modelling by Antonio Navarra & Simon Mason.

Numerical Models: Oceans



Source: Basics of numerical oceanic and coupled modelling by Antonio Navarra & Simon Mason.

What's a ROMS?

Regional Ocean Modeling System.

- ROMS is an ocean general circulation model that can be used on a variety of scales. It has been designed to excel in coastal applications but has been successfully implemented on larger scales.

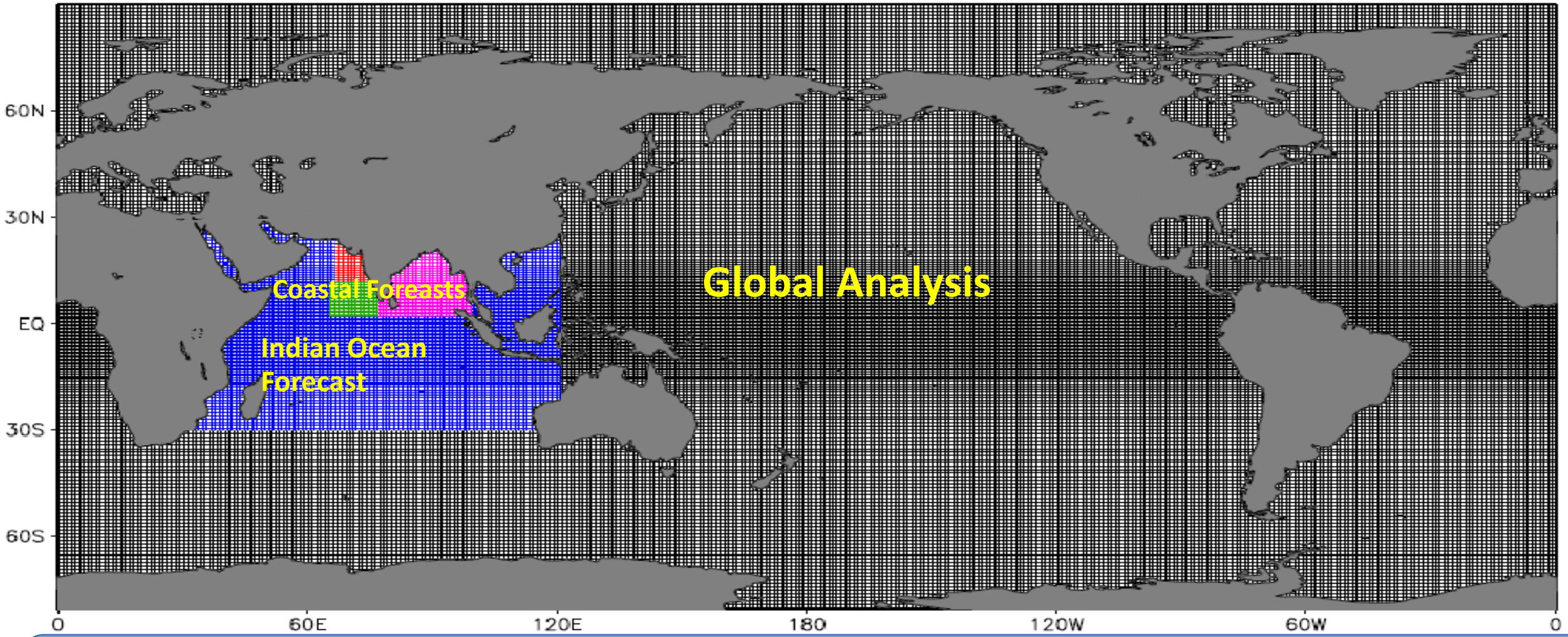
- Like other OGCM's it solves some approximation of the time-evolving three-dimensional equations for water motion in the ocean.

- ROMS is much more than a hydrodynamics code. It has biology, sediment, sea ice, etc. (ROMS > start)

Other ocean models…

- ACADIA, ACOM, ADcirc, BatTRI, BOM, BRIOS, DROG3D, CLIO, COHERENS, DIECAST, ECBILT, ECOM-SI, FLAME, FSM, FRAM, FUNDY, FVCOM, GMODEL, GOTM, HIM, HOPE, **HYCOM**, LOAM, LSM, MICOM, MITGCM, **MOM**, MOMA, NCOM, NLOM, NUBBLE, OCCAM, OCCOMM, OPA, OSMOM, PEQMOD, POCM, POM, POP, POSEIDON, POSUM, QTCM, QUODDY, **ROMS**, SCRUM, SEA, SEOM, SPEM, TOMS …

General Circulation Models- configured at the INCOIS



Global : GODAS (variable resolution, MOM4p0d + 3DVAR)
Indian Ocean : ROMS (~9.5 x 9.5 km) & HyCOM with red. KF(~ 7 x 7 km, experimental)
Coastal Ocean : ROMS (~ 2.25 x 2.25 km)

Steps to create an application (standalone ROMS)

Create input files (also can be generated analytically by Fortran code)

- Grid
- Forcing (atmospheric, river etc.)

Independent from vertical coordinates

- Boundary Condition (BC) - if domain has open boundaries
- Initial Condition (IC)
- Climatology - if nudging and/or relaxation are activated

create these files after vertical coordinates changed

Create configuration file (*.h)

- A set of CPP option must be defined such as advection, mixing, flux calculation etc.

Create namelist file (*.in)

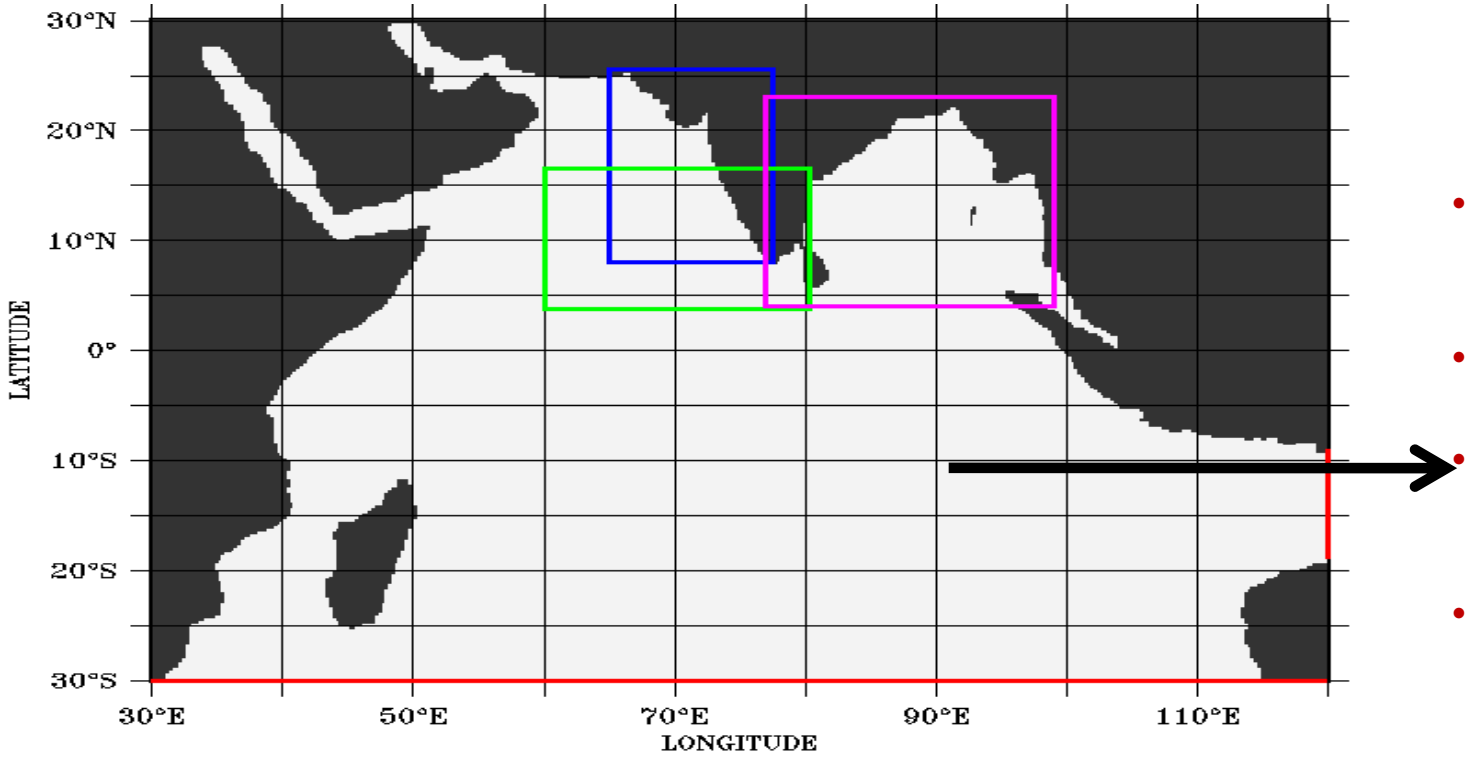
- User needs to edit namelist file based on the created application (additional namelist file exist for ICE model).

Run

- Edit machine specific definitions (Build/*.mk and build.sh)
- Run the model

Source: ICTP Course Materials

Bio-physical Model(s) in ESSO-INCOIS (Configured using ROMS v3.7)



WC-HOOFS, SEAS-HOOFS & BoB-HOOFS

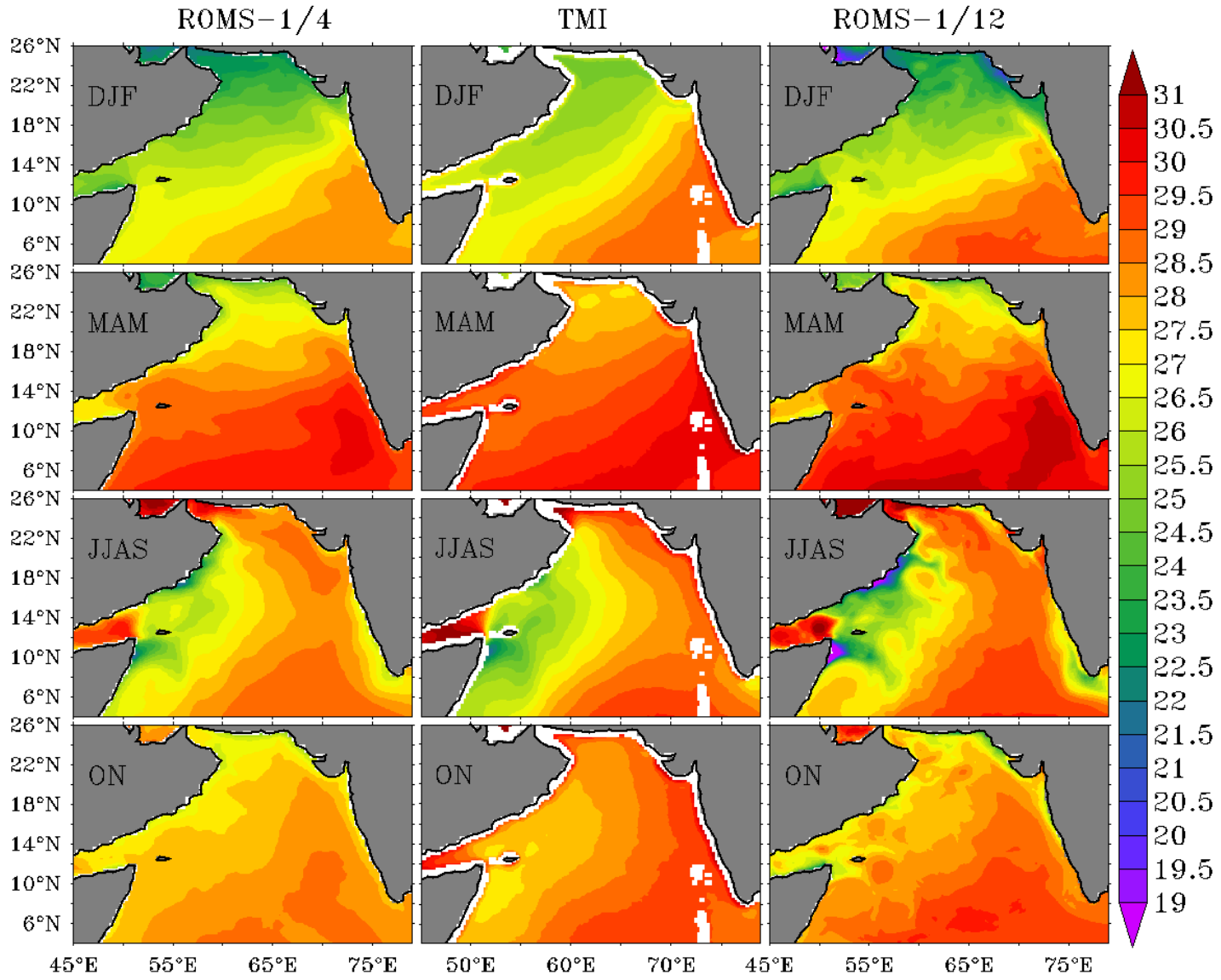
High Resolution Bio-Physical Model Configurations

- **Domain**
  65^0E to 77.5^0E, 08^0N to 26^0N,
  60^0E to 80.25^0E, 3.75^0N to 16.5^0N
  77^0E to 99^0E, 04^0N to 23^0N
- **Resolution**
  Horizontal : $1/48^0$ (~ 2.25 km) & Vertical: 40 sigma levels.
- **OBC** ROMS_1x12 (for all the bio-physical variables)
- **Vertical Mixing Scheme**
  KPP (Large et al., 1994).
- **Forcing** Winds and Fluxes from NCMRWF
- **Model simulation period**: Since 01-JAN-2010 ….

Model Configuration (Indian Ocean)

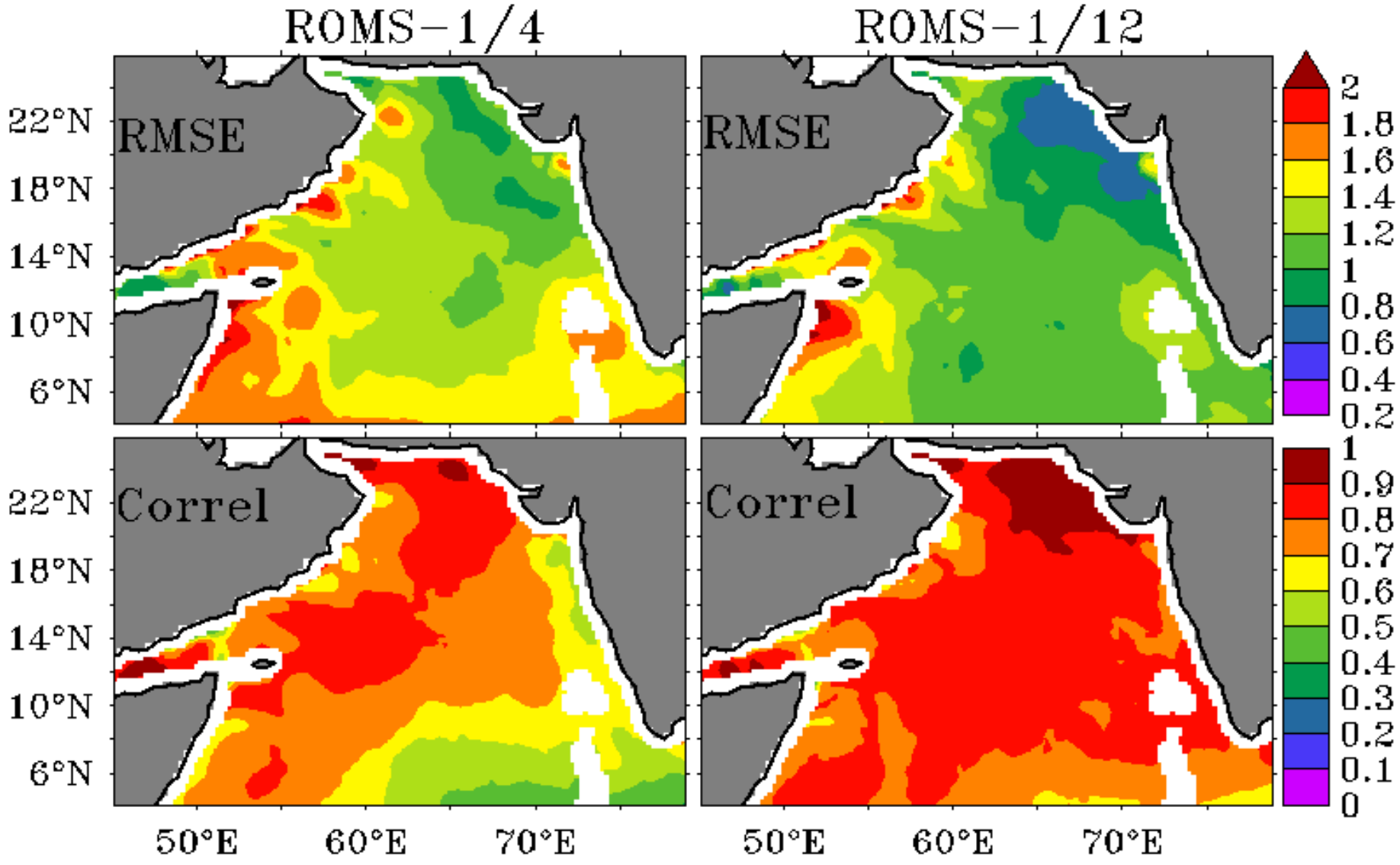
- **Model**
  Physical Model ROMS v3.7 coupled to an ecosystem model (Fennel et al., 2006).
- **Domain 10**
  30^0E to 120^0E, 30^0S to 30^0N.
- **Resolution**
  Horizontal : $1/12^0$ (~ 9.5 km),
  Vertical: 40 sigma levels.
- **Open boundaries: East and South**
  OBC: INCOIS-GODAS (for the physical model) and WOA 2013 (climatological for biological model)
- **Vertical Mixing Scheme**
  KPP (Large et al., 1994).
- **Forcing**
  Winds from NCMRWF
  Flux from NCMRWF
- **Model simulation period**
  01-JAN-2003 onwards…

Spatio-temporal variability of SST in the seasonal scale in the Arabian Sea



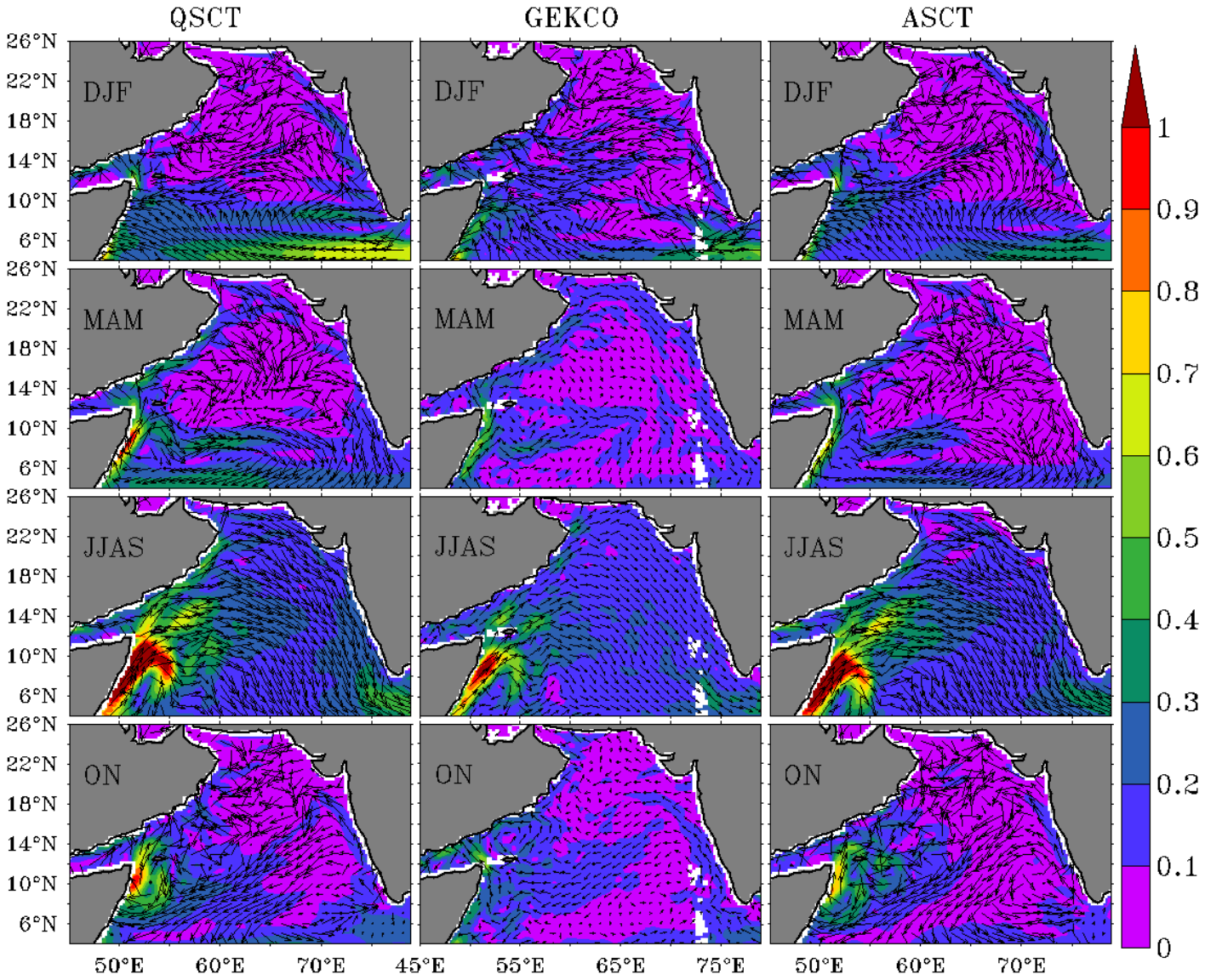
Multiyear average of seasonal composite ((first raw) December-February (second raw) March-May, (third raw) (June-September) and fourth raw (October-November) of SST (°C) obtained from ROMS-1/4 (left panel), Microwave Optimal Interpolated (MWOI) SST (middle panel) and ROMS-1/12 (right panel).

The correlation and Root-Mean-Square difference (RMSD) of SST between MWOI-SST and ROMS



The RMSD (top raw) and correlation (bottom raw) of SST estimated between ROMS-1/4 and MWOI-SST (left panels) and ROMS-1/12 and MWOI-SST (right panel).

Spatio-temporal variability of surface currents in the seasonal scale in the Arabian Sea



Comparison of seasonal mean surface currently derived from GEKCO (Obs) with those derived from identical ROMS biophysical ocean models forced separately by ASCAT (ASC) and QuickSCAT (QSC) wind-fields. Colour shading shows the magnitude while the vectors (of fixed length) show the direction, of the surface currents.

Operational ocean information and forecast services

Reliable forecast

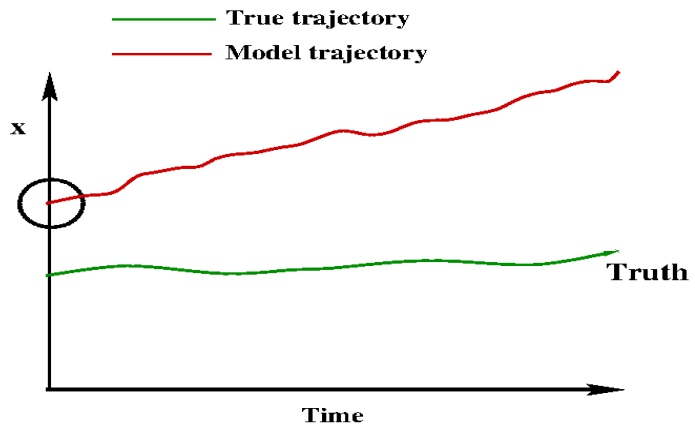
User defined products

The major challenge is to transform scientific knowledge into layman-understandable useful products. Integration of applied science, social science, sustained development plans, which lacks at present, is a must for a fruitful ocean forecasting system.

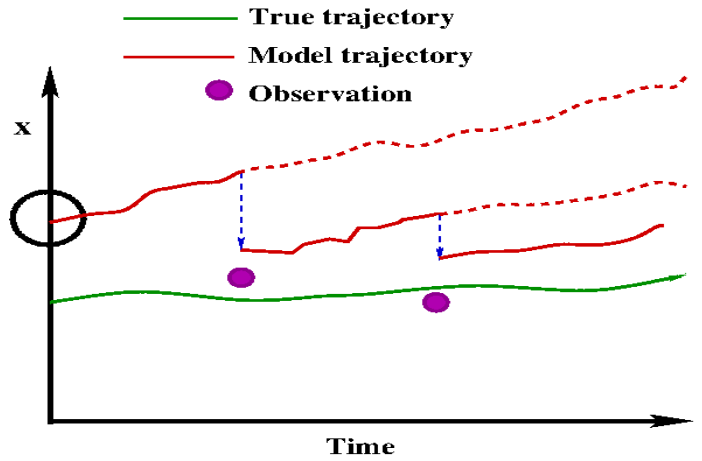
Ocean Modeling and Data Assimilation

- **Data assimilation is the process by which observations of a system are incorporated into the model state of a numerical model of that system. A numerical model determines how a model state at a particular time changes into the model state at a later time.**

- **Oceans are a kind of undersampled fluid system. Too sparse observations but the available observations can be made use to improve the forecasting capability of the ocean models.**

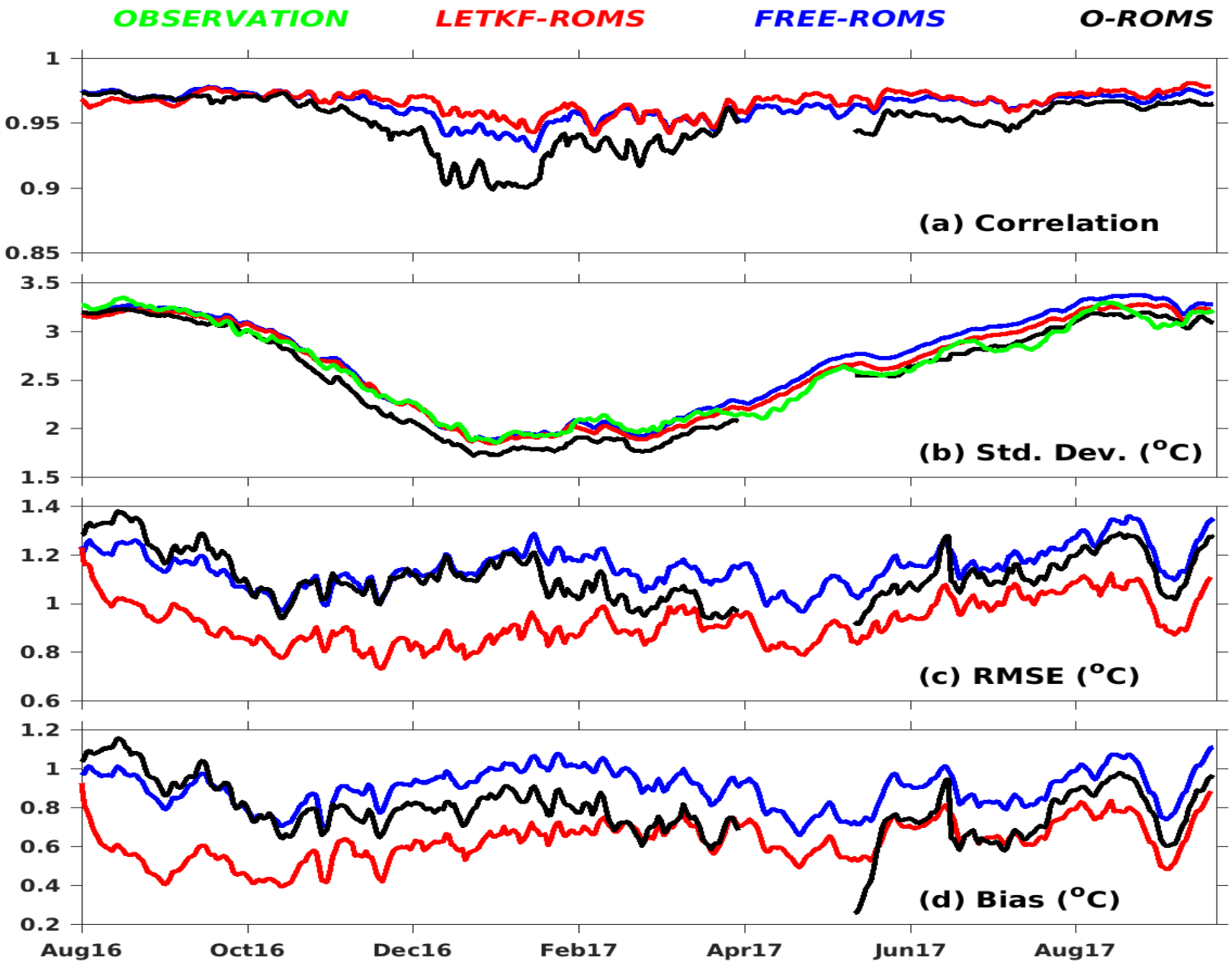


NO CORRECTION

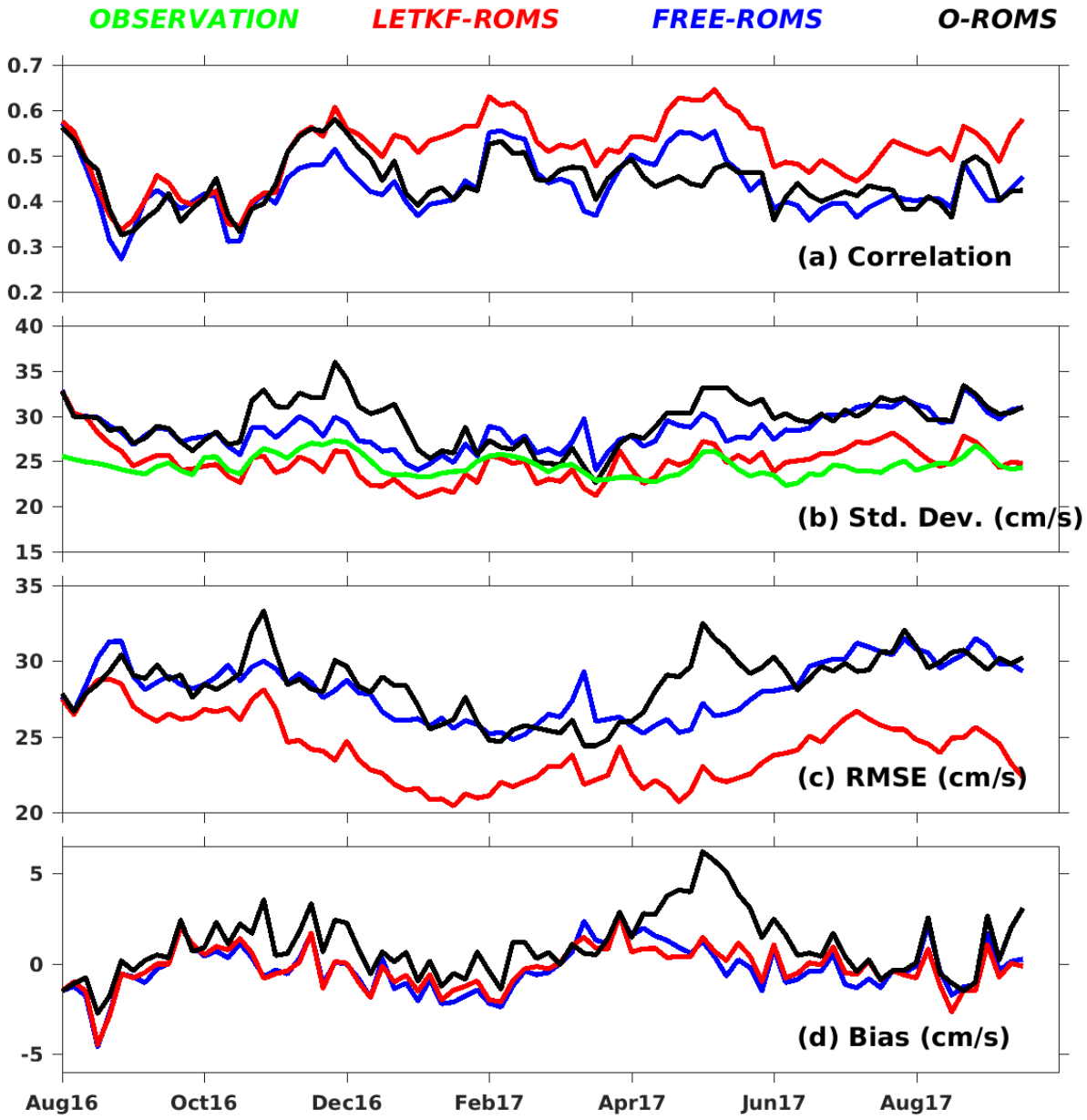


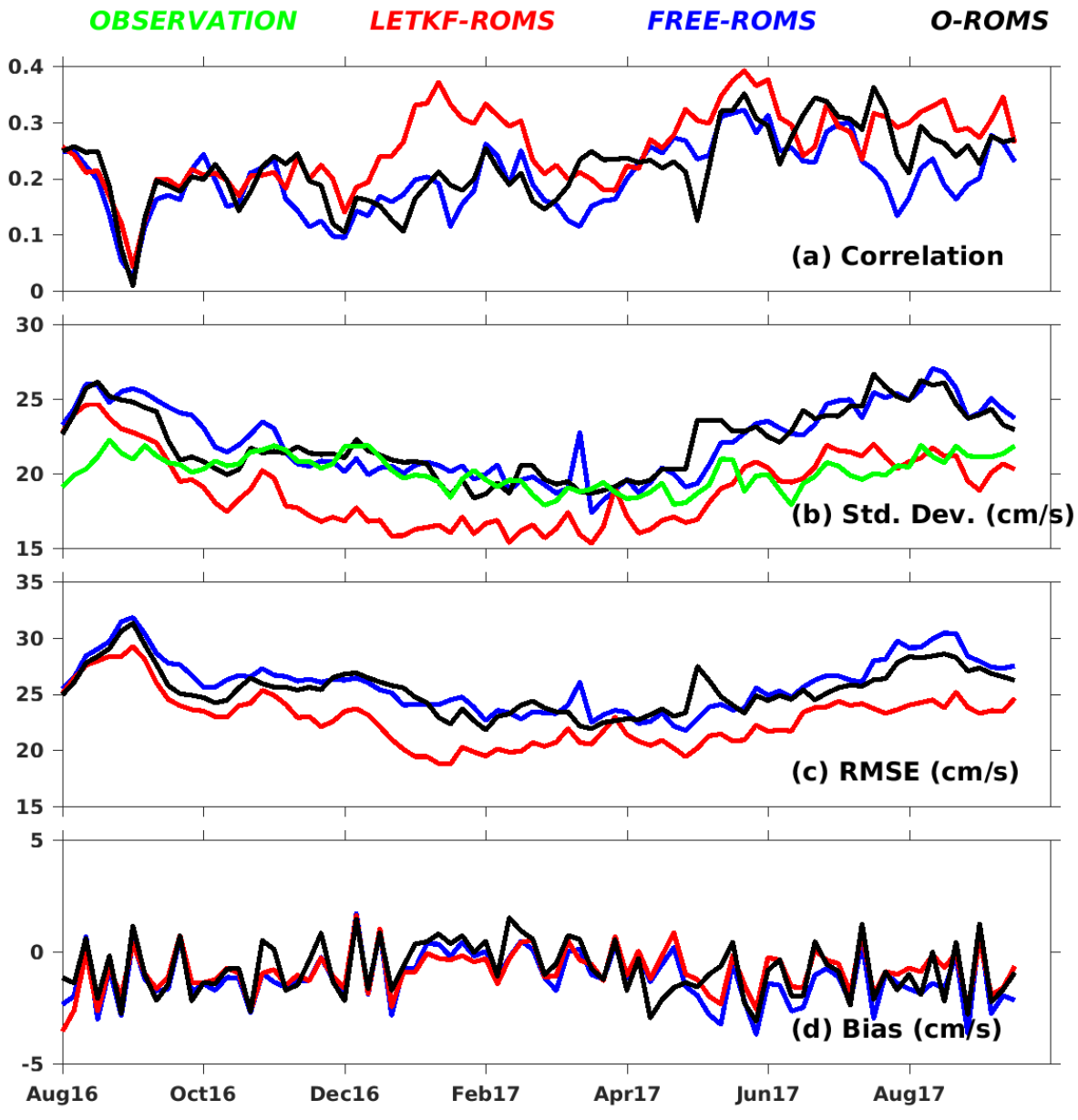
CORRECTION

Time series comparison of SST of LETKF, Operational ROMS, FREE ROMS against SST (AVHRR)

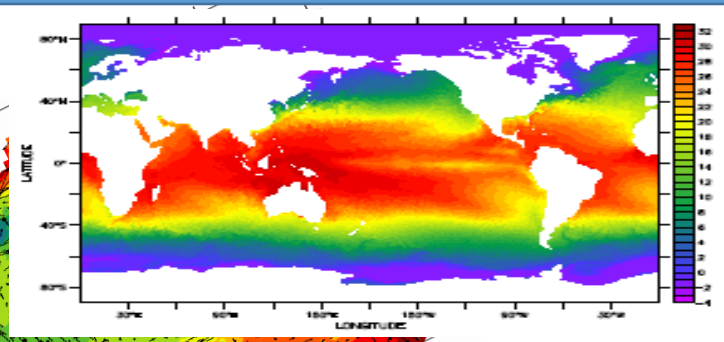


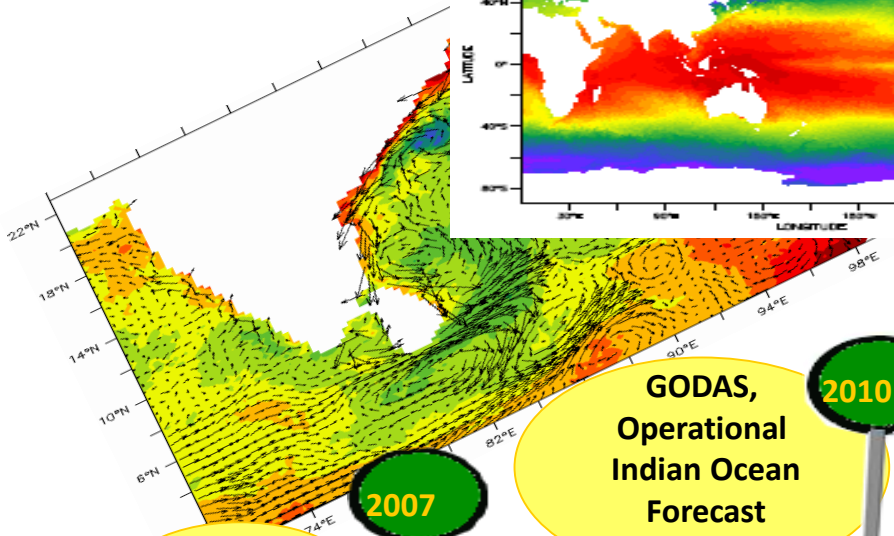
Time series comparison of zonal and meridonial currents of LETKF, Operational ROMS, FREE ROMS against OSKAR currents





Numerically predict the oceans.....



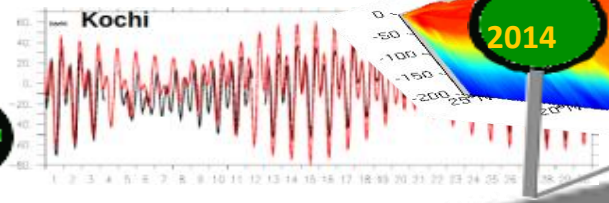


2007

Circulation modeling

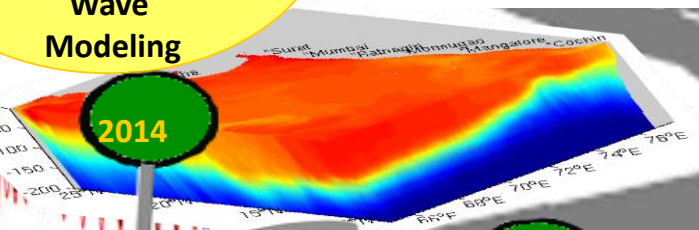
2010

GODAS, Operational Indian Ocean Forecast System



2014

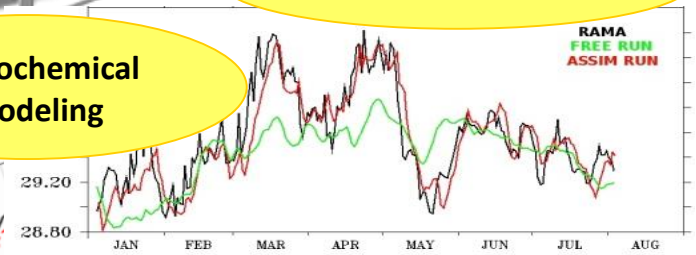
Tidal Modeling, WC-HOOFS, High resolution Wave Modeling



2015

2016

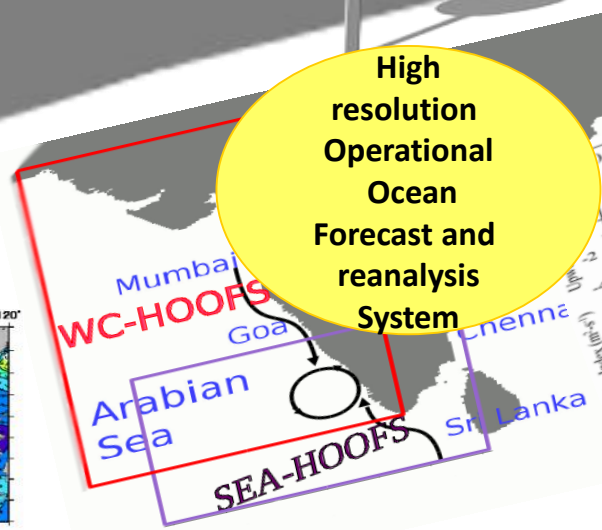
Data assimilation

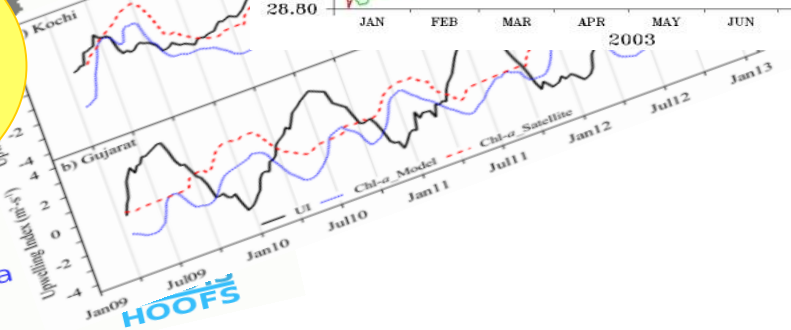


Biogeochemical Modeling

2013

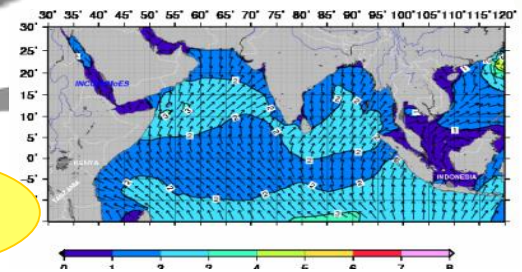
High resolution Operational Ocean Forecast and reanalysis System





2004

Wave modeling



Thank you for your attention!

Acknowledgement:

1. **Group Members, MDG, INCOIS**
2. **Director, INCOIS**
3. **OSF Team, INCOIS**