

Science of Weather

- Lectures in the morning (recorded)
- Practical work in the afternoon (experiments, data, clouds, presentations, role acting...)
- Topics: atmosphere, global circulation, extreme weather, clouds, weather forecasts, numerical models, data, WMO, climate...
- Grading: based on work in the afternoon, presentations and role acting participation

Weather Forecast or Horoscope
Just kidding...

Indians i meteorologists

The Indians on a remote reservation asked their new chief if the coming winter was going to be cold or mild. Just to be on a safe side the chief said yes and the Indians started gathering wood.

Few days later to get the correct info the chief went to the reservation's phone booth, called the National Weather Service and asked, "Will it be cold this winter?" "Yes!" the meteorologist replied.

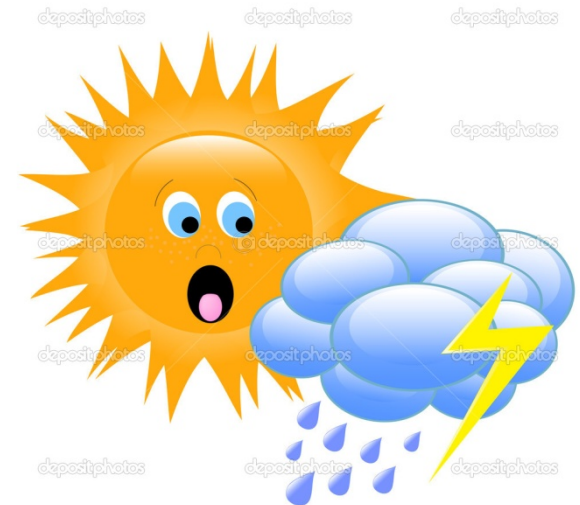
"How can you be so sure?" the chief asked.

"Simple," the weatherman replied, "The Indians are collecting a shitload of firewood."



Weather forecast

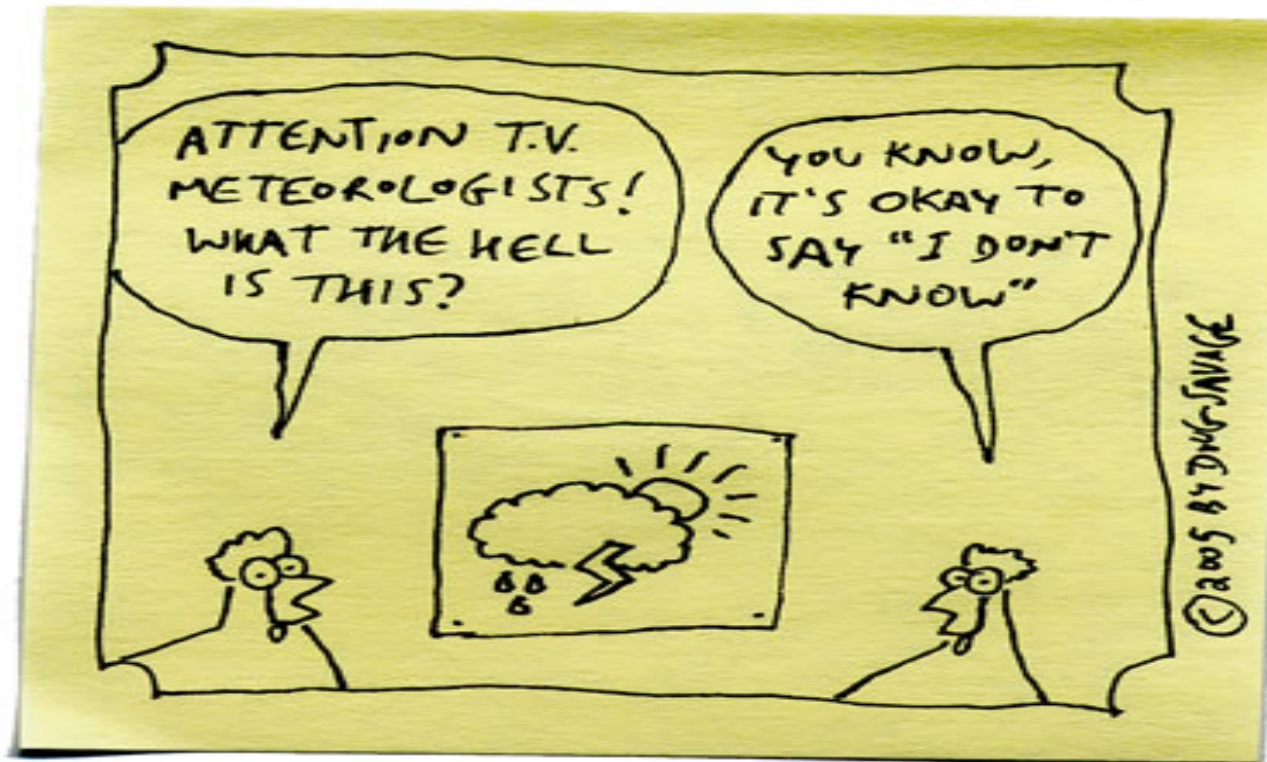
The weather tomorrow will be partly cloudy with periods of sun, with a possibility of rain or snow...



Why don't we just say: "I don't know."?


Savage Chickens

by Doug Savage



Historical overview

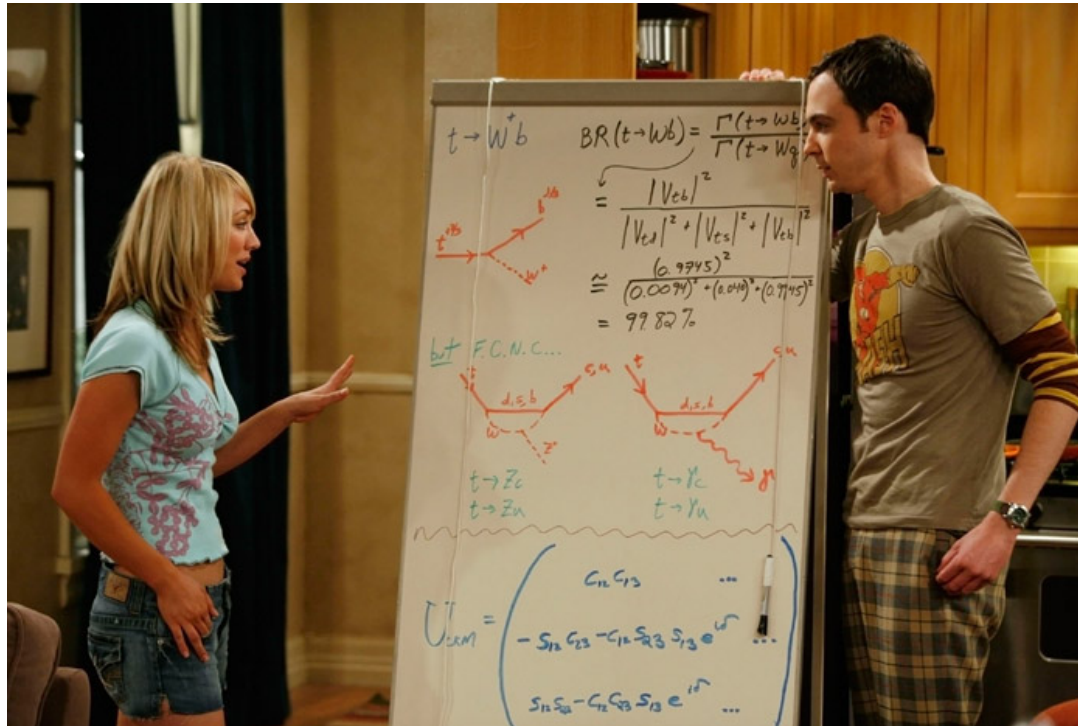
- * Word meteorology comes from Greek word *meteoron* - things
- * Vilham Bjerknes beginning of 20th century – math equations, Norwiegen
- * Charney 1948
- * ENIAC computer – numerical models

- 
- * Beginning of 20th century – at 2 points in EU they tried to calculate (paper and pencil) the forecast for 6 hours in advance – it took 6 weeks to get it.
 - * 1950s ENIAC – can solve the equations just in time...
 - * 1955 operational forecast in American meteorological organization

What goes into weather forecast?

Theory
Observations
Numerical models

Theory



Equations

$$3x=9$$

$$y = ax + b$$

$$\text{ODE} \quad \frac{dy(x)}{dx}$$

$$\text{PDE} \quad \frac{\partial T}{\partial t} + u \frac{\partial T}{\partial x} + v \frac{\partial T}{\partial y} + w \frac{\partial T}{\partial z}$$

Equations more...

Description of parcel in (x, y, z) and time (t)

Momentum equations

Continuity equation

Thermodynamic equations

Equations



Navier-Stokes Equations 3 - dimensional - unsteady

Glenn
Research
Center

Coordinates: (x,y,z)	Time: t	Pressure: p	Heat Flux: q
Velocity Components: (u,v,w)	Density: ρ	Stress: τ	Reynolds Number: Re
	Total Energy: Et		Prandtl Number: Pr

Continuity:
$$\frac{\partial \rho}{\partial t} + \frac{\partial(\rho u)}{\partial x} + \frac{\partial(\rho v)}{\partial y} + \frac{\partial(\rho w)}{\partial z} = 0$$

X - Momentum:
$$\frac{\partial(\rho u)}{\partial t} + \frac{\partial(\rho u^2)}{\partial x} + \frac{\partial(\rho uv)}{\partial y} + \frac{\partial(\rho uw)}{\partial z} = -\frac{\partial p}{\partial x} + \frac{1}{Re_r} \left[\frac{\partial \tau_{xx}}{\partial x} + \frac{\partial \tau_{xy}}{\partial y} + \frac{\partial \tau_{xz}}{\partial z} \right]$$

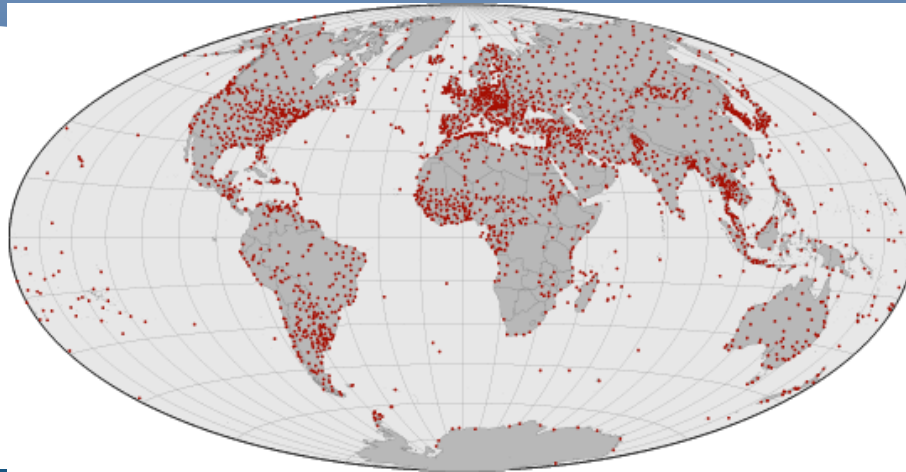
Y - Momentum:
$$\frac{\partial(\rho v)}{\partial t} + \frac{\partial(\rho uv)}{\partial x} + \frac{\partial(\rho v^2)}{\partial y} + \frac{\partial(\rho vw)}{\partial z} = -\frac{\partial p}{\partial y} + \frac{1}{Re_r} \left[\frac{\partial \tau_{xy}}{\partial x} + \frac{\partial \tau_{yy}}{\partial y} + \frac{\partial \tau_{yz}}{\partial z} \right]$$

Z - Momentum:
$$\frac{\partial(\rho w)}{\partial t} + \frac{\partial(\rho uw)}{\partial x} + \frac{\partial(\rho vw)}{\partial y} + \frac{\partial(\rho w^2)}{\partial z} = -\frac{\partial p}{\partial z} + \frac{1}{Re_r} \left[\frac{\partial \tau_{xz}}{\partial x} + \frac{\partial \tau_{yz}}{\partial y} + \frac{\partial \tau_{zz}}{\partial z} \right]$$

Energy:
$$\frac{\partial(E_T)}{\partial t} + \frac{\partial(uE_T)}{\partial x} + \frac{\partial(vE_T)}{\partial y} + \frac{\partial(wE_T)}{\partial z} = -\frac{\partial(up)}{\partial x} - \frac{\partial(vp)}{\partial y} - \frac{\partial(wp)}{\partial z} - \frac{1}{Re_r Pr_r} \left[\frac{\partial q_x}{\partial x} + \frac{\partial q_y}{\partial y} + \frac{\partial q_z}{\partial z} \right]$$

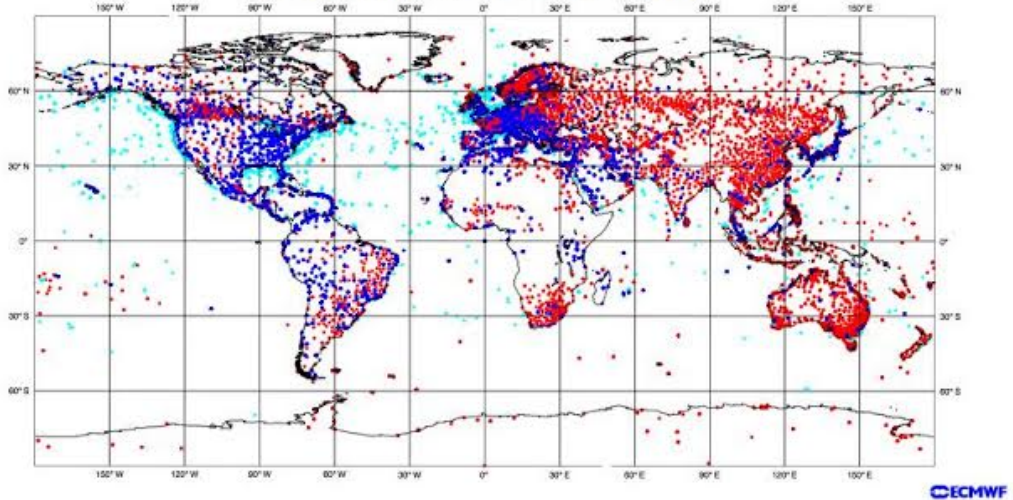
$$+ \frac{1}{Re_r} \left[\frac{\partial}{\partial x} (u \tau_{xx} + v \tau_{xy} + w \tau_{xz}) + \frac{\partial}{\partial y} (u \tau_{xy} + v \tau_{yy} + w \tau_{yz}) + \frac{\partial}{\partial z} (u \tau_{xz} + v \tau_{yz} + w \tau_{zz}) \right]$$

Observations





ECMWF Data Coverage (All obs DA) - SYNOP/SHIP
12/OCT/2007; 00 UTC
Total number of obs = 28181







September 1, 2001 to October 15, 2001

Project Location: East Pacific

Project Phase: Data Stewardship

Project Description:

The U.S. Climate Variability and Predictability (CLIVAR) program sponsored the field experiment **East Pacific Investigation of Climate Processes in the Coupled Ocean-Atmosphere System 2001 (EPIC2001)**, which has the goal of providing the observational basis needed to improve the representation of certain key physical processes in models.

In addition to physical processes, EPIC2001 research is directed toward a better understanding and simulation of the effects of short-term

DATA ACCESS

Data Access
Field Catalog

DATA DOCUMENTATION

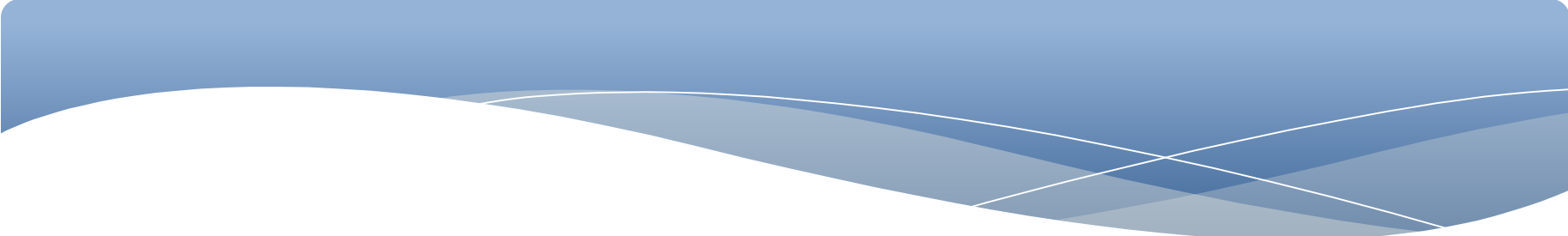
Data Policy
Data Set Documentation Guidelines
Data Submission Instructions

FACILITIES & PLATFORMS

C-130

PUBLICATIONS

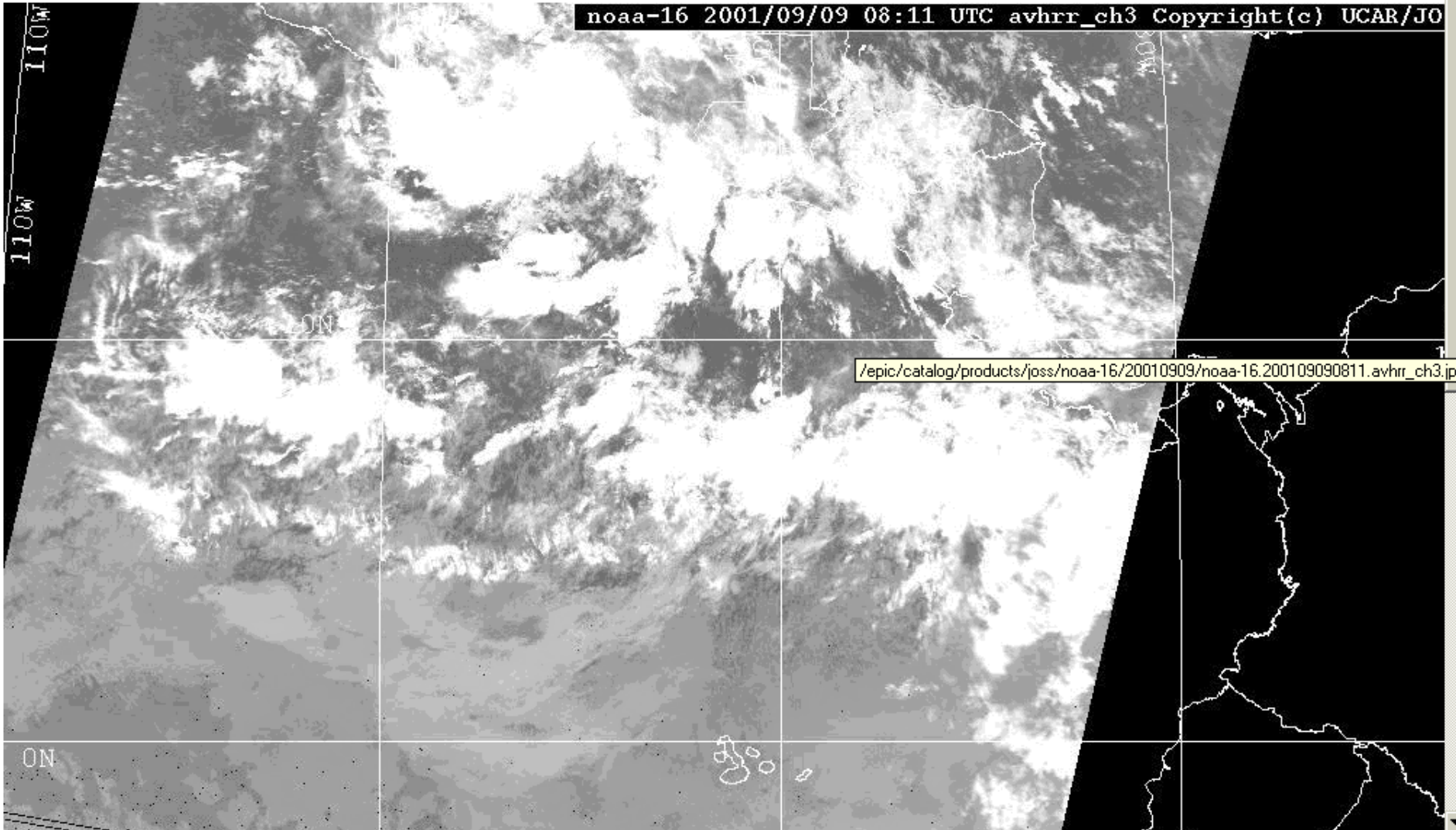
EPIC Publications



EPIC2001 was conceived as an intensive process study along and near 95°W during September and October 2001 used to make measurements of the atmosphere and ocean in this region.

- Two aircraft, the [National Center for Atmospheric Research's \(NCAR\) C-130](#) and [NOAA's P-3](#) aircraft (low altitudes)
- Two ships, NOAA's [R/V Ron H. Brown](#) and the National Science Foundation's (NSF's) R/V New Horizon
- Galapagos-based soundings

noaa-16 2001/09/09 08:11 UTC avhrr_ch3 Copyright(c) UCAR/JO



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110W
110W

110W

ON

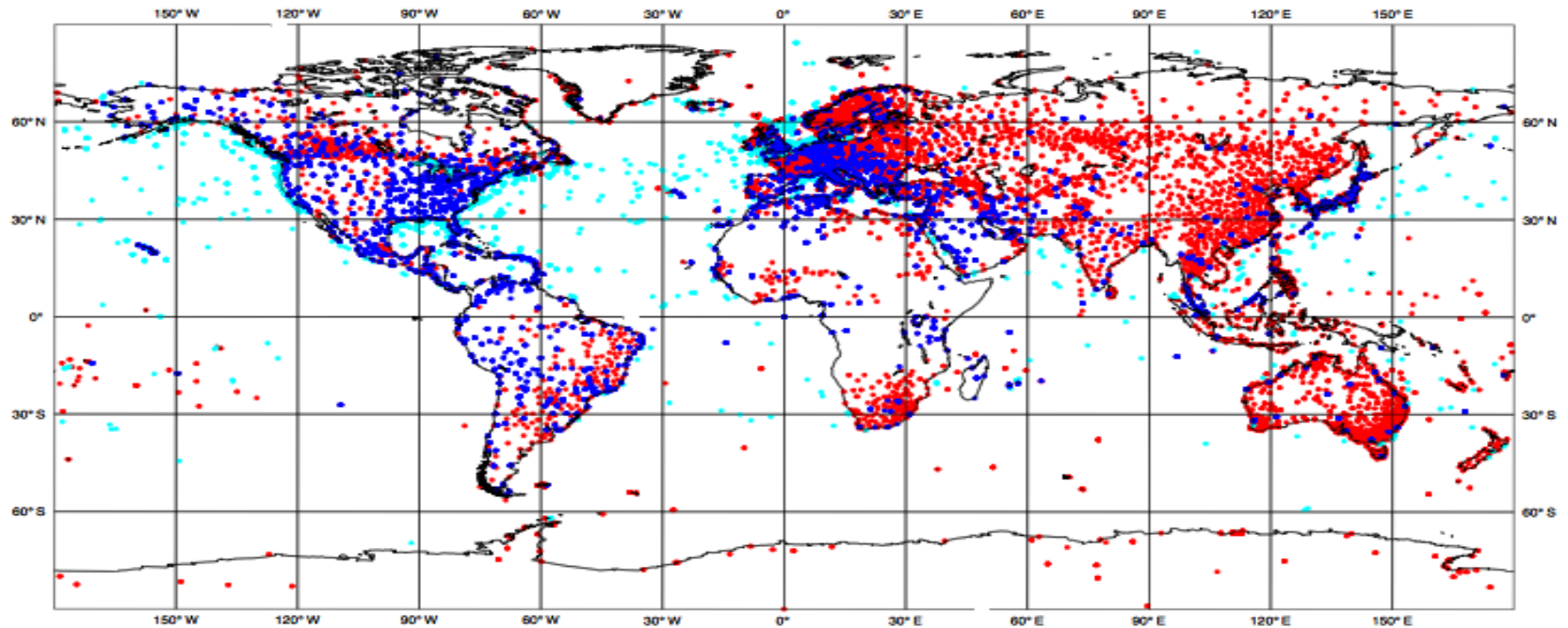
ON

ON

Obs Type

● 15885 SYNOP ● 2359 SHIP ● 9937 METAR

ECMWF Data Coverage (All obs DA) - SYNOP/SHIP 12/OCT/2007; 00 UTC Total number of obs = 28181



Huatulco airport



















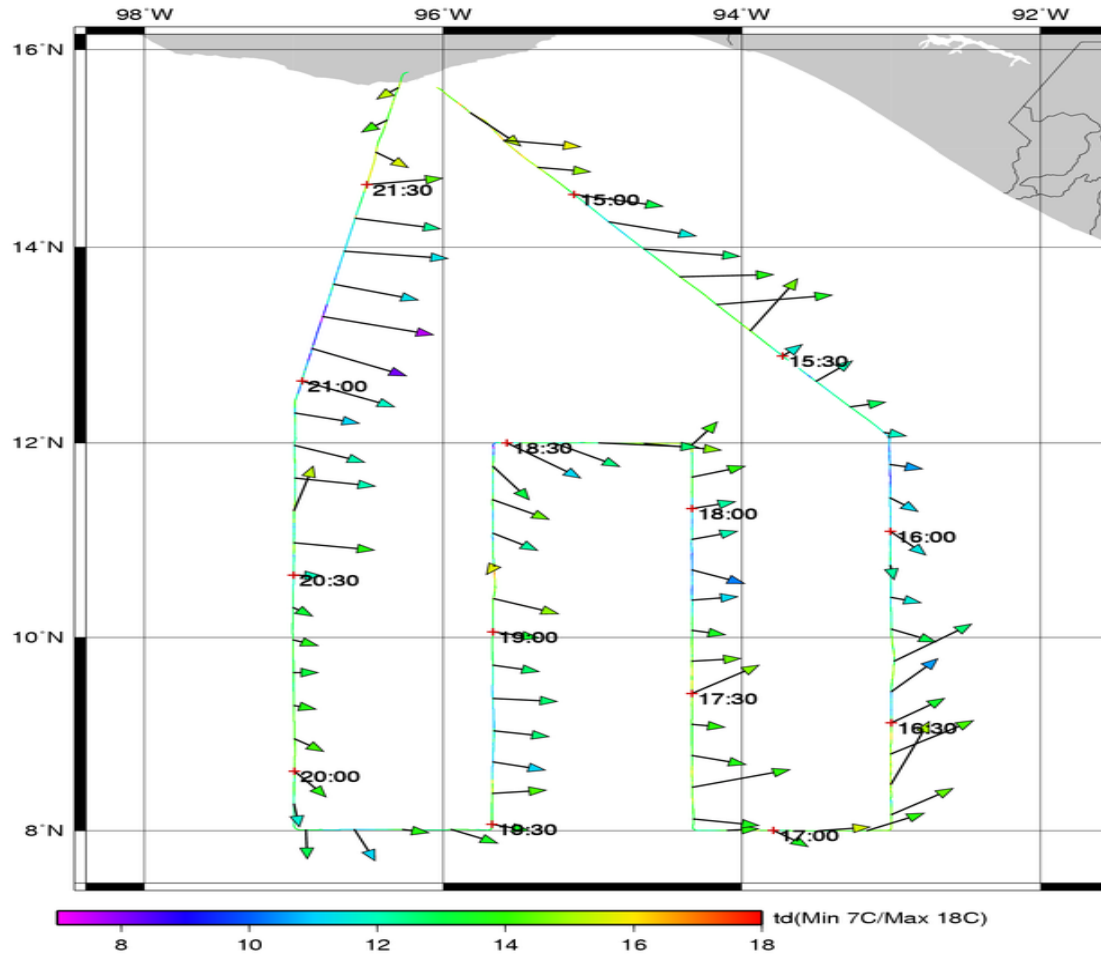




EPIC2001/HU01_N43/010909I

2001/09/09 14:40 - 2001/09/09 21:48 (UTC)

sla,slo -> td,ws,wd















Modeling



dreamstime.com



Computers



Numerical models

ECMWF

GFS

Regional models

Toy models

Weather forecast



SYNOP code – afternoon practicum

C_H $D_s v_s$
TT C_M PPP
VV ww **N** pp a
 ~~$T_d T_d$ C_L W_1~~
 ~~$T_w T_w$ N_h/h~~

SYNOP code – afternoon practice

03535 41470 82312 10077

20064 39981 40007 52012

72165 8682/

72365 11966 82504 10074

21001 39875 40157 52008

69901 70206 8807/