The scatterometers

(+ other wind measuring sensors)

Contributions to PBL theory & Modeling

The long, slow, tedious, semi-successful road to winds from space

- ✓Theory for Winds measurements
- ✓Satellite Measurements
  - ✓The scatterometer story
  - ✓The lidar challenge
  - ✓The Synthetic Aperture Radar (SAR) tale
- ✓**Results of Winds from Space**
- ✓**Politics**

Motivation

- Scatterometers measure water surface roughness as radar backscatter
- There is no theory for wind-wave generation
- The backscatter correlates to surface wind.
- There is significant error due to thermal stratification, wave-wave interaction, dynamic instabilities.
- For an accurate correlation (better than ± 2 m/s) forget Ekman's linear solution & diffusion modeling of turbulence.
- A nonlinear solution exists since 1970; complex but getting easier, parameterized.


Theory

The Mathematical solution for the flow in the boundary layer with a rotating frame of reference (a PBL)

- 1970: the analytic solution is a modified Ekman solution based on a rough K-theory for small-scale turbulence plus a large-scale coherent structure [Organized Large Eddies (OLE) = 'Rolls'].

  [see Ralph Foster: ralph@apl.washington.edu & pbl.atmos.washington.edu]

- 2000s: Applications in NCEP & NASA PBL models using simple parameterizations (*Rolls for Dummies*)

  [see Jerome Patoux: jerome@washington.edu]

R. A. Brown 2008

End of Theory
Look at data

Satellite Observations

In the beginning there exists a measurement

Emissivity (radiometer, SMMR, SSMI….)

backscatter (σ_o) (SASS. SAR. Alt.)

Doppler (lidars)

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Practical Aspects of Wind Measurements available for parameterization with σ_o

Surface 'Truth' Limits

Ship winds: Sparse and inaccurate (except some Met. Ships).

Buoy winds: Sparse; a point. Tilt; variable height; inadequate PBL modelling – they miss high winds and low wind directions.

GCM winds: Bad physics in PBL Models; Too low high winds, too high low winds. Resolution coarse (getting better).

11-99, 5/00, 2/08 RAB

Practical Aspects of a Geostrophic Wind Model Function (implied Surface Pressure fields)

Surface 'Truth' Limits (pressure fields)

Buoy and ship pressures: Sparce but accurate in low and high wind regimes.

GCM: Good verification; compatible scale

Bonus: wind vectors from scatterometer only

Applications

Better GCM Progs

Better Storms Definition

Higher Winds (heat fluxes) in Weather & Climate models

Proof of Rolls (OLE) Ubiquity

And on & on *ad infinitum*…..

The Scatterometer

A Brief History of Scatterometers

1970

Conception

SeaSat Built --- with Scat, SAR, SMMR, Alt

SeaSat Launch --- Lasts 99 days, but sensors proven

NSCAT conceived and built

1980

Earth Science Dark Ages:

Launch $ to Gulf & Carribean wars, Refurbish battleships, 200 ship fleet, Star Wars

1990

ERS-1 Launch by ESA

NSCAT launched on ADEOS I --- 9 mos.

ERS-2 Launch

Quikscat Launch

SeaWinds on ADEOS – II, ---3 mos

2000

Dark Ages – II USA? Gulf wars, Mars mission, Space Station Star Wars II

2010

ESA A-SCAT

Aladdin (lidar)

R. A. Brown 1/2008

The SAR

Status of SARs in Space

- There are no US wind SARs

- There is a private/Canadian SAR, Radarsat --- data too expensive for research

The Liar

Lidar PBL possibilities

Wind vectors between satellite and surface

Initialization for Weather & Climate Models

Roll details

Aerosol statistics

Inversion height

PBL turbulence spectrum

Surface characteristics

R. A. Brown 2000; 2008

Status of Lidars in Space

- There are no US Lidars (non-military)
- Sparkle (on shuttle) was cancelled by Congress (earmark) for a private satellite 'data buy' study 2000.

Company declared bankruptcy 2006

- There is a planned Lidar circa 2010 by Europe


A
conspiracy
Theory

Generation of an Inferiority Complex

1986-90. EOS Payload Panel; Scatterometer chosen by panel, then deleted by NASA (3X)

1991. LAWS (the EOS doppler lidar) deselected.

2000. Lidar earmarked to private firm. NASA sets up Data Buy branch.

Generation of a Conspiracy Theory

- Sen. Imhoff suggests that climate warming is a hoax by climate scientists. Michael Creighton writes a scenario to this effect which is cited by talk radio, politicians (and at least one scientist) as the truth (albeit written as fiction).

2005 (written, 1996). In another fiction story, a 1-paragraph Big Oil conspiracy plot made circa 1978 "We can supply oil and control energy for 100 years. The only thing that will stop us is global warming. We must discredit it" (in "The Tree or the Panzaic Plea").

If Michael Crieghton can write fiction as science, I can write science as fiction.

Generation of a Conspiracy Theory

2006. Attended NOAA (lidar) followed by NASA (QS & windsat) satellite team meetings where each satellite had been cancelled.

- Gave short paper: *ad hoc*, (whimsical?) "Who killed the scatterometer?"
  - Hansen testimony before congress accuses "Big Oil" of being behind the suppression of Global Warming information 2007
  - Suggested delete any references to climate warming in proposals.

2006 & Positive feedback.

2007 The Proenza Affair

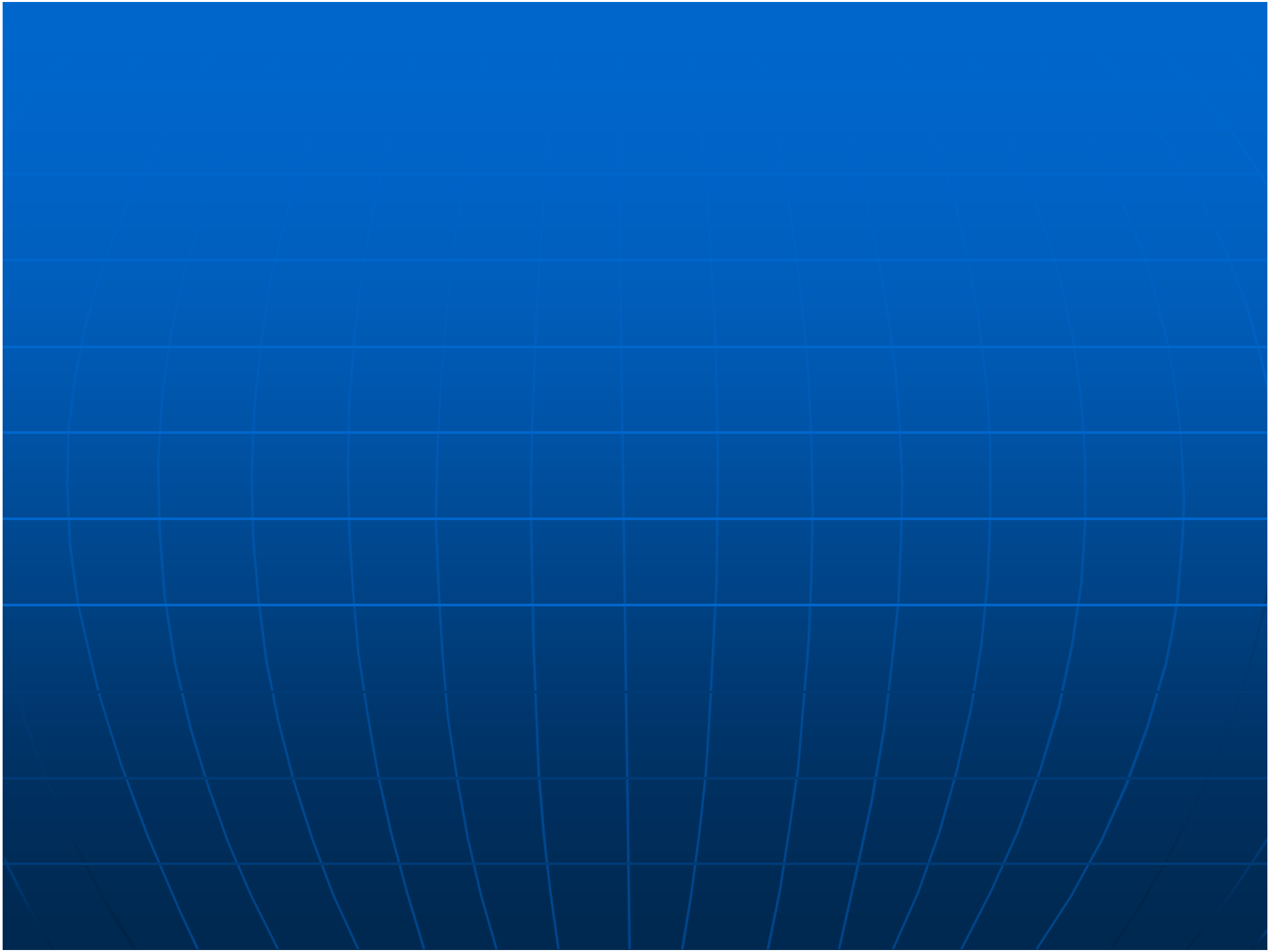
e.g. NAS/decadal report; UN report…

Generation of a conspiracy theory

QED

The End?

Or
the beginning of a new era (11/08).



http://pbl.atmos.washington.edu

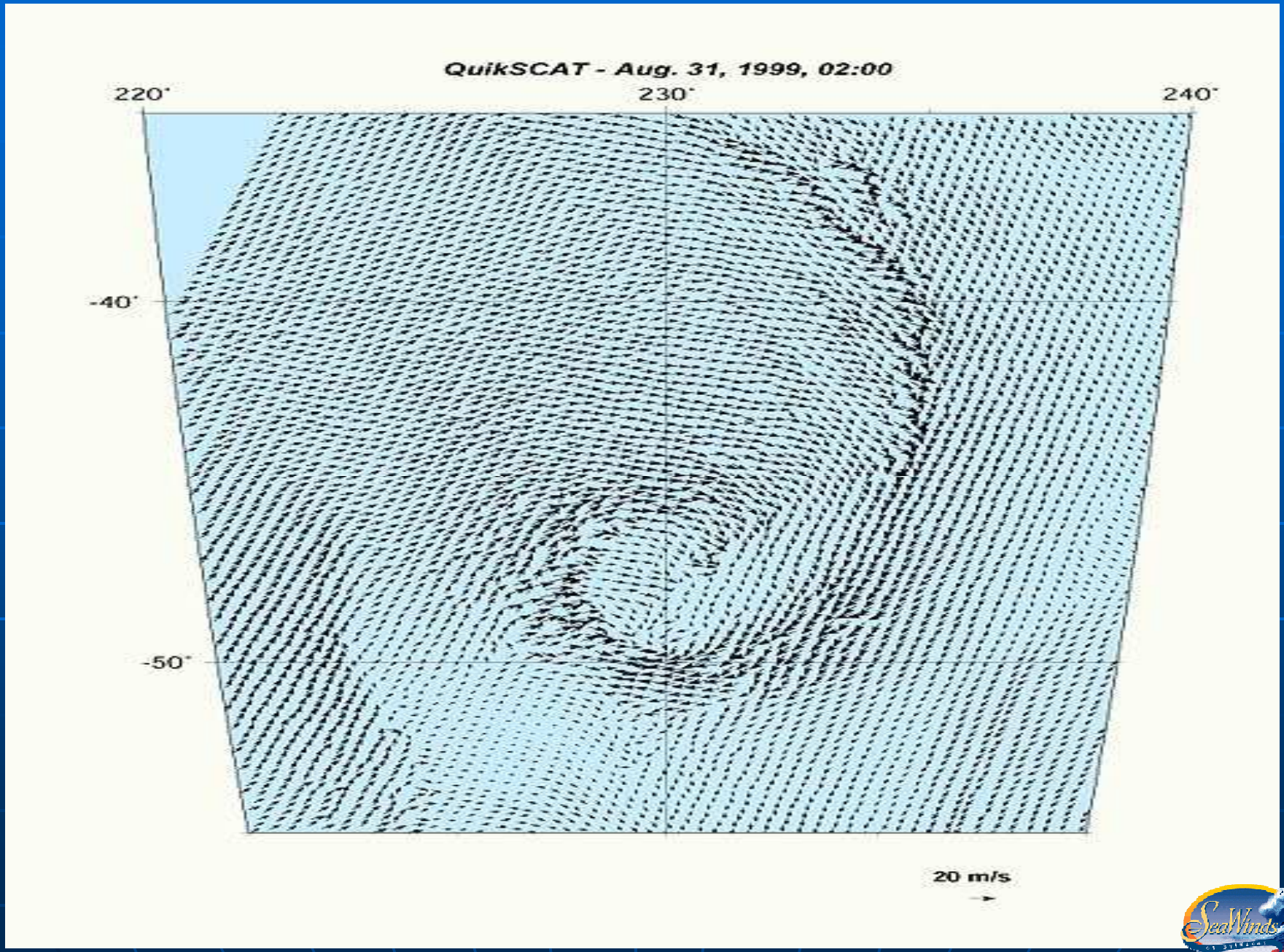
Please direct any feedback to rabrown, neal or jerome@atmos.washington.edu

- Programs/information available:
- **Direct PBL model**: PBL_LIB. ('75 -'00) An analytic solution for the PBL flow with rolls, U(z) = f(∇P, ΔT_o , ∇T_a , λ)
- The **Inverse PBL model**: Takes U_{10} field and calculates surface pressure field
  ∇P (U_{10} , ΔT_o , ∇T_a , λ) (1986 - 2000)
- Pressure fields directly from the **PMF**: ∇P (σ_o) along all swaths (exclude 0 - $\pm$ 5° lat.?) (2010)
- Surface stress fields from PBL_LIB corrected for stratification effects along all swaths (2008)

- PhD Thesis: A secondary flow model for the PBL, advisor: Bob Fleagle '69 ---
  "*Rolls theory --- the end of diffusion models*"
- AIDJEX Project: Get winds over Arctic Ocean '74 --- Birth of PBL model w/Organized Large Eddies
  "*A two-layer similarity PBL Model with Rolls*"
- SeaSat Satellite '78: Show that getting U_{10} to $\pm$0.1 m/s from 800km impossible ----
  "*Can't verify it or believe it.*"
- Publish: The Scatterometer as an Anemometer. *J. Geophys. Res.*, **88**, C3, 1663-1673, 1983 --
  "*U_{10} to $\pm$1 m/s is good enough for a lot of science.*"
- PI for: Scatterometers (SASS, ERS1/2, NSCAT, QuikScat, SeaWinds); Lidars: (LAWS, Sparkle, Alladin?); Radiometers; (SMMR, SSMI); 1978 - present "*It's a great job & someone gets to do it.*"

Credentials for being a Climate Model Critic (& Conspiracy aficionado)

- ***Analytic Methods in Planetary Boundary Layer Modeling,*** Adam Hilger LTD., London, and Halstead Press, John Wiley and Sons, New York. 150 pp, 1974. Translated to Russian (1975), Chinese (1982), Korean, (1980). (*One of the weakest point of general circulation models*).
- ***Fluid Mechanics of the Atmosphere***, International Geophysics Series, **47**, Academic Press, San Diego, 460pp, Jan., 1991. (*The derivation of the basic equations of climate modeling*.)
- **On PBL Models for general circulation models**, *The Global Atmos.-Ocean System*, (R.A. Brown & Ralph Foster), **2**, 163-183, 1994. (*They're bad*.)
- ***Remote Sensing of the Pacific Ocean by Satellites,*** R.A. Brown, Editor, Earth Ocean & Space PTY LTD, New South Wales, Aust., Southwood Press Pty Limited, Marrickville Australia, pp. 454, 1998. (*Observational proof of above*.)
- ***The Tree, or the Panzaic Plea***, an adventure novel about meaning of life, 486 pp, 2005. Available Amazon.com; Barnes&Nobel and University Book Store, UW. (*Since nonscientists are running the show, a novel for them --- with philosophy slipped in between violence & sex*.)



R. A. Brown 2003 U. Concepción

1978 - SeaSat

Scatterometer Products from Space *Marine Surface*

WIND vectors

Surface stress vector

2000

Scatterometer Products From Space-*Marine Surface*

WIND vectors

Pressure Fields

Pack Ice location, concentration, thickness

Land Vegetation

Fronts

Storms: Location Strength

Mean PBL temperature

Surface stress vector

Mean PBL stratification

Scatterometers in Space

SeaSat 1978

ERS -1 1991-95

NSCAT 1996-97

ERS-2 1995-2004

QuickScat 1999-

SeaWinds I 2002

ASCAT 2007-

Model Function History

Assume: $\sigma_o \sim \mathbf{u^*} \sim U_{10}$

Observe good correspondence; σ_o (U_{10})

Develop $\mathbf{U_{10}} \sim \sigma_o$ Model Function

Get good correspondence; U_G [$u^*(U_{10})$]

Develop $U_G \sim \nabla \mathbf{P} \propto \mathbf{U_{10}}(\sigma_o)$ Model

Get good correspondence; ∇P [(U_{10} (σ_o)]

Develop $\nabla \mathbf{P} \sim \sigma_o$ Model Function

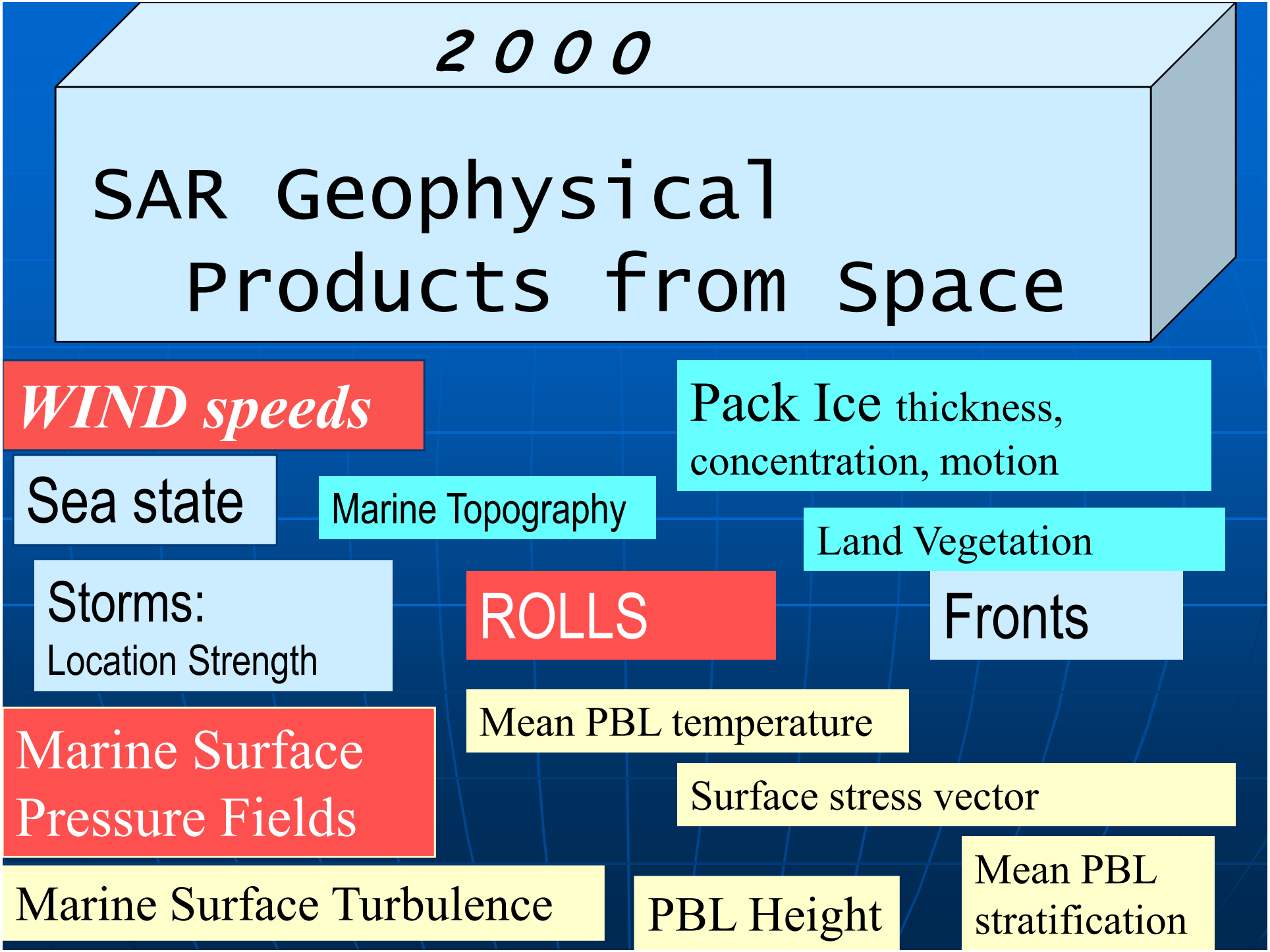
R. A. Brown 2008

1978 - SeaSat

SAR Geophysical Products from Space

Sea state: roughness, swell

WIND speeds


2000
SAR Geophysical Products from Space
WIND speeds
Pack Ice thickness, concentration, motion
Sea state
Marine Topography
Land Vegetation
Storms: Location Strength
ROLLS
Fronts
Mean PBL temperature
Marine Surface Pressure Fields
Surface stress vector
Marine Surface Turbulence
PBL Height
Mean PBL stratification

Some of the Exciting Results from Remotely Sensing Winds

Revelations 1

Compared to what is found in GCMs and climatology records, Storms are:

- Often misplaced
- Stronger (deeper Pressures)
- More frequent

Revelations 2

- **There exist large regions of High Winds (1000 km^2/storm) that nobody knows of……**
- These do not appear in:
- GCM analyses
- Buoy data
- Climate data

R. A. Brown 1/2000; 2008

Revelations 3

- There exist Fronts (particularly in So. H.) that no one know of: new concepts
- --- Defined as lines of different sea state (roughness variation) => wind change

  These fronts are:
- Ubiquitous
- Persistent
- Mysterious (e.g. no storm in sight)

Revelations 4

- Real time forecasts (NCEP) are improved using Quikscat surface pressure fields

The Bill Proenza Affair

June, 2007. Meeting with Bob Atlas, [illegible]

- February, 2007. Brown corners Proenza at a party, gives Quikscat party line -- it improves hurricane forecasts 10%. [illegible] scat

April, 2007. 22 NHC forecasters sign memo criticizing Proenza

[illegible] support. He admits forecasters actually support [illegible]

Proenza fired by NOAA -- NHC needs a [illegible]

Bob sends letter to Miami paper [illegible] Proenza was right, 22 should be fired.

Atlas testifies that Proenza was right. (Bob takes some credit).

Accusations of Conspiracy

- Sen. Imhoff suggests that climate warming is a hoax by climate scientists. Michael Creighton writes a scenario to this effect which is cited by talk radio, politicians (and at least one scientist) as the truth (albeit written as fiction)
- Brown presents "Who Killed the Scatterometer?" at NASA meeting in 2006 (patterened after documentary "Who Killed the Electric Car?") At first, coy, as in documentary, then specific -- big oil
- Hansen testimony before congress accuses "Big Oil" of being behind the suppression of Global Warming information 2007

SCATTEROMETERS

- There have been continuous scatterometers (with ESAs) since 1978 providing the only global wind field; better surface pressure fields than NCEP or ECMWF; better forecasts
  - → Arbitrarily Discontinued in 2006

There is an ESA ASCAT 2007; and Indian, Japanese, Russian planned.

Radiometers

- Wind Speed only, (the lesser threat), Navy SSMI 1990 – 2006 without press release.
  - Windsat (2-looks for vector wind) placed on NPOESS operational satellite in 2005 2006: Windsat follow-on abruptly cancelled. No data released for a year. Then very good wind vector data for 3 months released.

(Because it really didn't get the wind vectors, -- or because it did?)

SARS

- SEASAT SAR 1978 - 99 days

  Space Shuttle 1980s SIR A & B; and other topography missions 1994
- RADARSAT 1995.
- ESA ERS satellites, 1991; JERS-1, Envisat ASAR

Private Canadian data buy; expensive

LIDARS

- 2000. Sparkle (on shuttle) was cancelled by Congress (due to an earmark) for a private satellite data buy study.
- LAWS cancelled in 1999

Alladin by ESA in 2010.

company declared bankruptcy 2006

US funding sporatic & small

DSCOVR

- 2000. The Deep Space Climate Observatory (DSCOVR) was supposed to be delivered seven years ago to the L1 Lagrangian point—a gravity-neutral parking spot between the Earth and the sun that affords a continuous, sunlit view of the planet. From here, DSCOVR would measure the planet's energy balance and relay satellite data for calibrating climate change models and monitoring the ozone layer.
  - The mission was quietly killed (2006) so the satellite is sitting in a box at Goddard Space Flight Center.

NASA refused free rides from France & Ukrain