Targeted observation strategies in DOTSTAR

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Outline
– About DOTSTAR
– Targeted observations in DOTSTAR
– Adjoint-Derived Sensitivity Vector
– Future plans
Flow chart of DOTSTAR

Astra jet

GPS Dropsonde

Satellite communication

AVAPS
On-board data reception

Global/TC model

JMA, UKMO, KMA

NCEP/FNMOC

in real time

CWB

Global/TC model
(Inform. Center)

NTU/Research team
Archive Research

Ana./Fct. (Forecasting center)
DOTSTAR obs. in 2003 & 2004

10 TCs, 12 missions, 58 flight hours, with 192 GPS dropwindsondes released.

An average 20% improvement for the 12-72h track forecasts in AVN.

(Wu et al. 2004, BAMS)
Targeted observation strategies in DOTSTAR

AVN ensemble variance
(collaborating with Aberson)

AVN ETKF
(collaborating with Majumdar)

– NOGAPS Singular Vector (collaborating with Reynolds)
MM5 adjoint sensitivity for the targeted obs. in DOTSTAR

• Theoretical work on the determination of the targeted observation strategy for improving the typhoon track prediction has been lacking in literature.

• Along with the progress in DOTSTAR, we propose a new method to determine the sensitive area for targeted observation in DOTSTAR based on the adjoint sensitivity.

  • Suitable Response function(s) should be designed to represent the steering flow at the verifying time, and to assess the adjoint sensitivity with respect to such Response function(s).

  • We also wish to design some simple parameter that can interpret the above sensitivity with clear physical meanings.
Experiment design

- **Model**: MM5 Adjoint Modeling System
  - (Zou et al. 1997)
  - (Wu et al. 2004, JAS)
  - (Kleist and Morgan, 2004, MWR)

- **Case**: Typhoon Mindulle
  - (a starting test case)

Up to now, the DOTSTAR dropsonde data have shown an average 20% improvement of the 12-72-h typhoon track forecasts in AVN. Nevertheless, Mindulle is the sole case that does not show positive impact!
**Goal**: To identify the sensitivity areas at **1200 UTC 27 June**, that will affect the **steering flow** of Typhoon Mindulle at **0000 UTC 29 June**.
- **Verified area:**

  A box is centered at the forecast position of Typhoon Mindulle at **0000 UTC 29 June**.

  **Verifying area (A)**
  - 600 km × 600 km
  - 121 grid points
Experiment design

• **Response function**: A unique new definition to represent the steering flow.

Define the average wind field within the verifying area at the verifying time

\[
R_1 = \frac{\int_{300\text{hPa}}^{850\text{hPa}} \int_{A}^{} u \, dx \, dy \, dp}{\int_{300\text{hPa}}^{850\text{hPa}} \int_{A}^{} dx \, dy \, dp}
\]

\[
R_2 = \frac{\int_{300\text{hPa}}^{850\text{hPa}} \int_{A}^{} v \, dx \, dy \, dp}{\int_{300\text{hPa}}^{850\text{hPa}} \int_{A}^{} dx \, dy \, dp}
\]

\[(R_1, R_2) = \text{steering flow at the verifying time}\]
Results

• **R₁ sensitivity at - 0 h**

We can combine \( \frac{\partial R_1}{\partial u} \) and \( \frac{\partial R_1}{\partial v} \) to obtain \( \frac{\partial R_1}{\partial \zeta} \), which is physically more meaningful and comprehensible.
• Higher sensitivity in $R_2$ than in $R_1$
Results

- Adjoint-Derived Sensitivity Vector (ADSV)
  - A unique new definition to identify the sensitive (and targeted observing) areas to the steering flow at the verifying time.

\[
\text{ADSV} = \left( \frac{\partial R_1}{\partial \varsigma}, \frac{\partial R_2}{\partial \varsigma} \right)
\]

**Magnitude** – the degree of sensitivity

**Direction** – the response of the steering flow direction w.r.t. the vorticity variation.
Sensitivity vector of steering flow, 700hPa
• Higher sensitivity to the northeast of Mindulle
• More impact on the meridional movement
- Compared with other sensitivity products

Adjoint sensitivity Vector (ADSV)

ETKF Signal variance (shaded)

NOGAPS SV

DLM ensemble Variance (shaded)
Future work

- **Linearity test**
  - To validate the linearity assumption, perturbations that evolves linearly via the TLM need to be compared with difference fields obtained from two nonlinear model forecasts.

- **Impact study**
  -- In order to validate the MM5 adjoint modeling system, we will modify the wind/temperature fields in the initial time based on the ADSV sensitivity areas to investigate the response of the simulated typhoon track.

- **Other case studies**
  - A thorough investigation of other DOTSTAR cases, such as Meari and Nock-Ten, is ongoing.
  - Test specific event: such as trough effect, binary interaction…
  - Detailed comparisons of different targeted technique.
  - Data-denial experiments and diagnosis.

- **Operation in the field program**
  - We plan to implement the currently designed method (using ADSV) for real-time use in DOTSTAR in 2005.