

SABER blocks in PR #145  
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Extension in future PRs  
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Other ongoing tasks  
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## JEDI Algorithms meeting - SABER blocks



SABER blocks in PR #145

Extension in future PRs

Other ongoing tasks

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# Static background error covariance matrix



A typical static B :

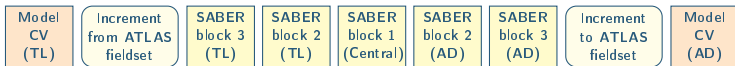
$$B = K_{\text{model}} \underbrace{K_{\text{BUMP}} \Sigma C_{\text{BUMP}} \Sigma^T K_{\text{BUMP}}^T}_{\text{SABER}} K_{\text{model}}^T$$

# Static background error covariance matrix



A typical static B :

$$B = K_{\text{model}} \underbrace{K_{\text{BUMP}} \Sigma C_{\text{BUMP}} \Sigma^T K_{\text{BUMP}}^T}_{\text{SABER}} K_{\text{model}}^T$$





# Static background error covariance matrix

A typical static B :

$$B = K_{\text{model}} \underbrace{K_{\text{BUMP}} \Sigma C_{\text{BUMP}} \Sigma^T K_{\text{BUMP}}^T}_{\text{SABER}} K_{\text{model}}^T$$

Model CV (TL)	Increment from ATLAS fieldset	SABER block 3 (TL)	SABER block 2 (TL)	SABER block 1 (Central)	SABER block 2 (AD)	SABER block 3 (AD)	Increment to ATLAS fieldset	Model CV (AD)
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The `SaberBlockBase` class and its parameters are instantiated in a factory, depending on the `saber block name` :

- `BUMP_NICAS` : NICAS smoother of BUMP
- `BUMP_PsiChiToUV` : psi-chi to u-v convertor of BUMP
- `BUMP_StdDev` : standard-deviation loaded through BUMP
- `BUMP_VerticalBalance` : vertical balance of BUMP
- `ID` : identity operator
- `GSI_RF` : empty shell for the recursive filters.
- `StdDev` : standard-deviation directly loaded from a file.

# Static background error covariance matrix



```
background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]
```

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]
  
```

}  $C_{\text{BUMP}}$   
 }  $\Sigma$   
 }  $K_{\text{BUMP}}$   
 }  $K_{\text{model}}$

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]
  
```

$\left. \begin{array}{l} \text{BUMP\_NICAS} \\ \text{StdDev} \end{array} \right\} C_{\text{BUMP}}$   
 $\left. \begin{array}{l} \text{StdDev} \\ \text{BUMP\_VerticalBalance} \end{array} \right\} \Sigma$   
 $\left. \begin{array}{l} \text{BUMP\_VerticalBalance} \end{array} \right\} K_{\text{BUMP}}$   
 $\left. \begin{array}{l} \text{Control2Analysis} \end{array} \right\} K_{\text{model}}$

**covariance model:** is now SABER instead of BUMP.



# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]

```

$C_{\text{BUMP}}$   
 $\Sigma$   
 $K_{\text{BUMP}}$   
 $K_{\text{model}}$

The **saber block name** is required for each block.

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]
  
```

$C_{\text{BUMP}}$   
 $\Sigma$   
 $K_{\text{BUMP}}$   
 $K_{\text{model}}$

The central block is indicated by `saber central block: true`.  
 If missing or set to false,  $C_{\text{BUMP}} C_{\text{BUMP}}^T$  is applied instead of  $C_{\text{BUMP}}$ .

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]
  
```

}  $C_{\text{BUMP}}$   
 }  $\Sigma$   
 }  $K_{\text{BUMP}}$   
 }  $K_{\text{model}}$

GMRESR is used to inverse a block if `iterative inverse: true`  
 (useful if a block does not have an explicit inverse).

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]
  
```

$C_{\text{BUMP}}$   
 $\Sigma$   
 $K_{\text{BUMP}}$   
 $K_{\text{model}}$

The **input** and **output variables** are required for each block.

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]

```

$C_{\text{BUMP}}$   
 $\Sigma$   
 $K_{\text{BUMP}}$   
 $K_{\text{model}}$

The **active variables** are effectively used by this block,  
other variables are kept unchanged.

If missing, **active variables** are set to **input variables**.

# Static background error covariance matrix



```

background error:
covariance model: SABER
saber blocks:
- saber block name: BUMP_NICAS
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  bump:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
variable changes:
- variable change: Control2Analysis
  input variables: [psi, chi, t, ps, rh]
  output variables: [ua, va, t, ps, sphum]

```

$C_{\text{BUMP}}$   
 $\Sigma$   
 $K_{\text{BUMP}}$   
 $K_{\text{model}}$

Block-specific parameters are specified in sub-configurations like

**bump** or **file**

# Localization matrix



Localization of a sampled covariance matrix  $\tilde{B}$ :

$$B = L \circ \tilde{B}$$

```

background error:
  covariance model: ensemble
  members:
- [...]
- [...]
- [...]
  localization:
    localization method: SABER
    saber block:
      saber block name: BUMP_NICAS
      input variables: [psi, chi, t, ps, rh]
      output variables: [psi, chi, t, ps, rh]
      bump:
      [...]
  
```

}  $\tilde{B}$

} L

A single **saber block** is specified for L.  
This could be updated in the future if needed.

# JEDI Algorithms meeting - SABER blocks



SABER blocks in PR #145

Extension in future PRs

Other ongoing tasks





## Mixing operators

- It is already possible to mix operators from different SABER components, but they should **have the same geometry**.
- If a geometry change is required, the interpolation operator **P** should be explicited as a **saber block**.

$$B = K_{\text{BUMP}} \Sigma P C_{\text{GSIRF}} P^T \Sigma^T K_{\text{BUMP}}^T$$

Increment from ATLAS fieldset	SABER block 4 (TL)	SABER block 3 (TL)	SABER block 2 (TL)	SABER block 1 (Central)	SABER block 2 (AD)	SABER block 3 (AD)	SABER block 4 (AD)	Increment to ATLAS fieldset
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where **P** is an interpolator from the Gaussian grid (used by GSIRF) to the native grid (used by all other blocks).

# Mixing operators



```
background error:
covariance model: SABER
saber blocks:
- saber block name: GSI_RF
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  gsirf:
  [...]
- saber block name: Interpolator
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  interpolation method: BUMP
  input grid:
  [...]
  output grid:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
```

} CGSIRF

} P

}  $\Sigma$ }  $K_{\text{BUMP}}$



# Mixing operators

```
background error:
covariance model: SABER
saber blocks:
- saber block name: GSI_RF
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  gsirf:
  [...]
- saber block name: Interpolator
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  interpolation method: BUMP
  input grid:
  [...]
  output grid:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
```

} CGSIRF

} P

}  $\Sigma$

}  $K_{\text{BUMP}}$

Specific block name and sub-configuration for the recursive filters.

# Mixing operators



```
background error:
covariance model: SABER
saber blocks:
- saber block name: GSI_RF
  saber central block: true
  iterative inverse: true
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  gsirf:
  [...]
- saber block name: Interpolator
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  interpolation method: BUMP
  input grid:
  [...]
  output grid:
  [...]
- saber block name: StdDev
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  file:
  [...]
- saber block name: BUMP_VerticalBalance
  input variables: [psi, chi, t, ps, rh]
  output variables: [psi, chi, t, ps, rh]
  active variables: [psi, chi, t, ps]
  bump:
  [...]
```

} CGSIRF

} P

}  $\Sigma$ }  $K_{\text{BUMP}}$ 

Explicit interpolator: method and input/output ATLAS grids.

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Extension in future PRs  
ooooo

Other ongoing tasks  
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## JEDI Algorithms meeting - SABER blocks



SABER blocks in PR #145

Extension in future PRs

Other ongoing tasks

## Other ongoing tasks



- Better fitting procedure in BUMP (almost finalized).
- Handling humidity correctly:
  1. pseudo-relative humidity (implicit cross-covariance).
  2. normalized relative humidity (implicit cross-covariance).
  3. specific humidity (explicit cross-covariance as Holm *et al.* 2002).
- Localization with multiple length-scales (currently buggy).
- Re-implementation of the “network” method for NICAS.
- $C^1$  interpolation from the unstructured grid.
- etc.

Any questions?